Materials in Design Engineering

FORMERLY
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AUG 14 1958
ENGINEERING
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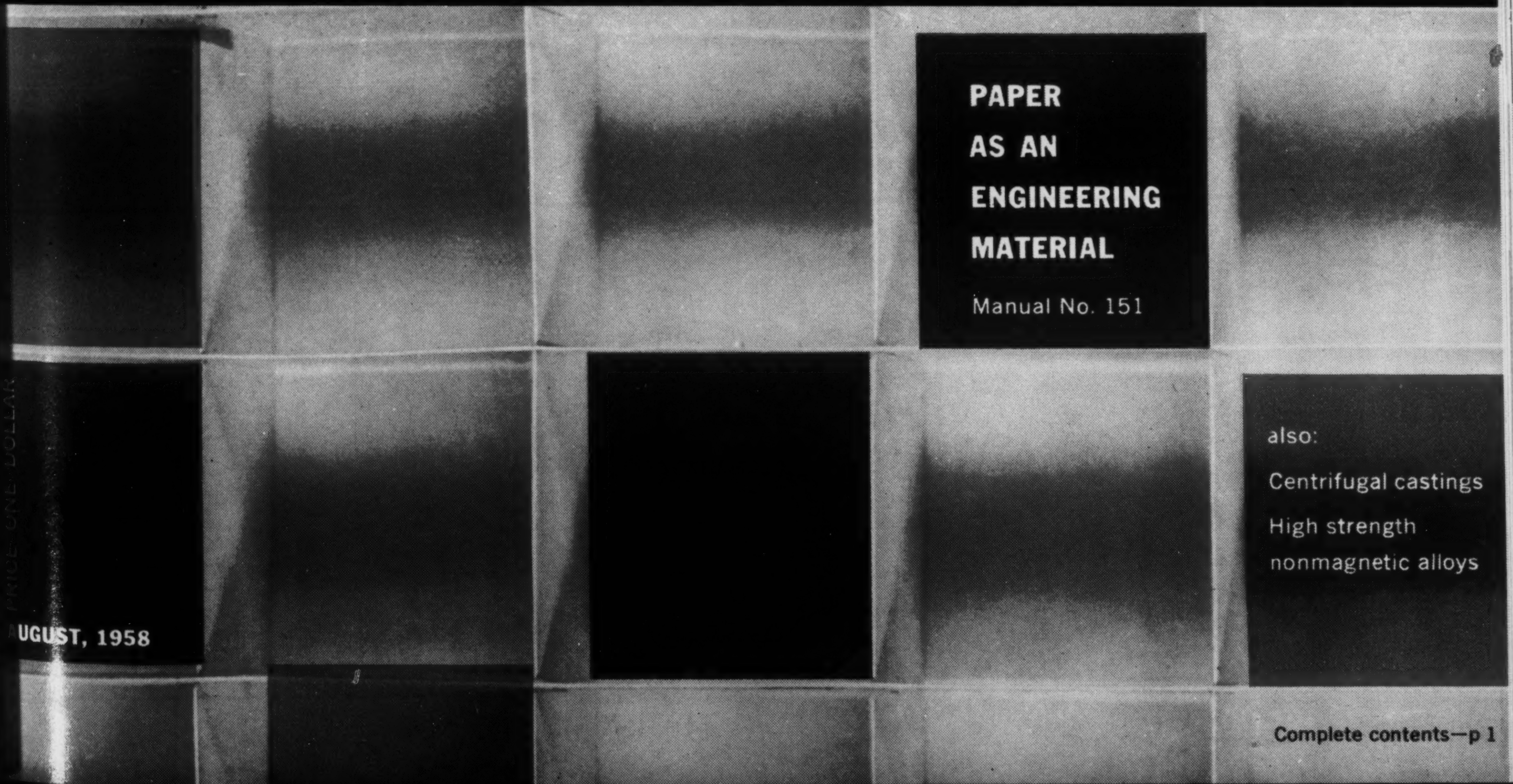
SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



PAPER AS AN ENGINEERING MATERIAL

Manual No. 151

also:

Centrifugal castings

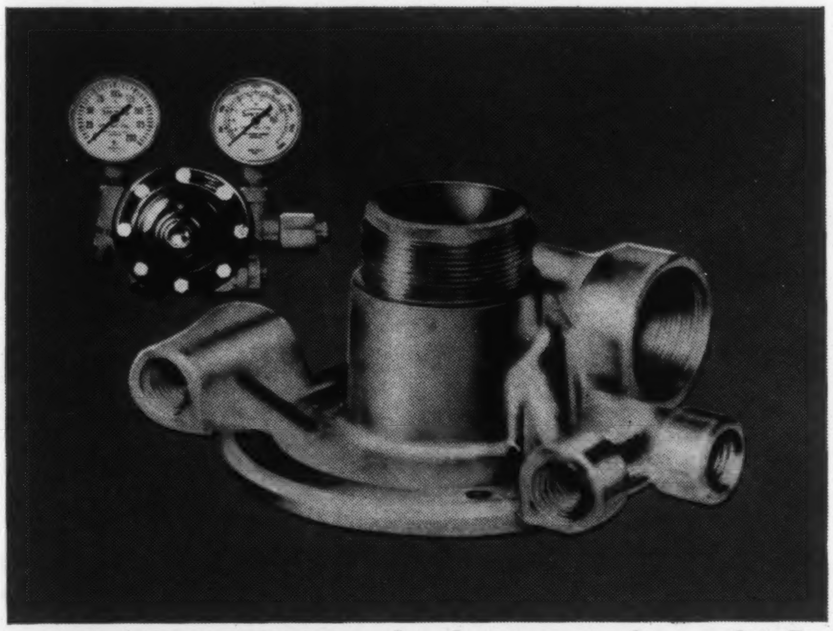
High strength nonmagnetic alloys

PRICE ONE DOLLAR

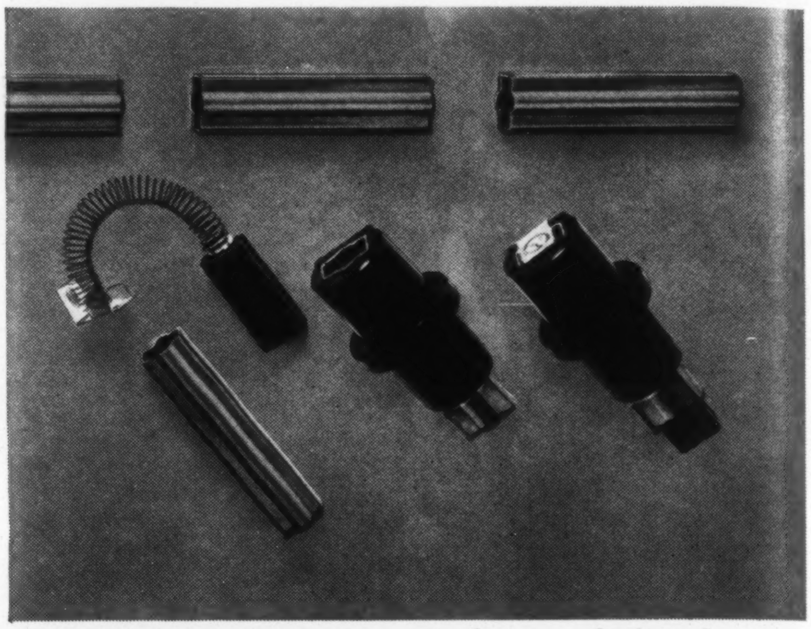
AUGUST, 1958

Complete contents—p 1

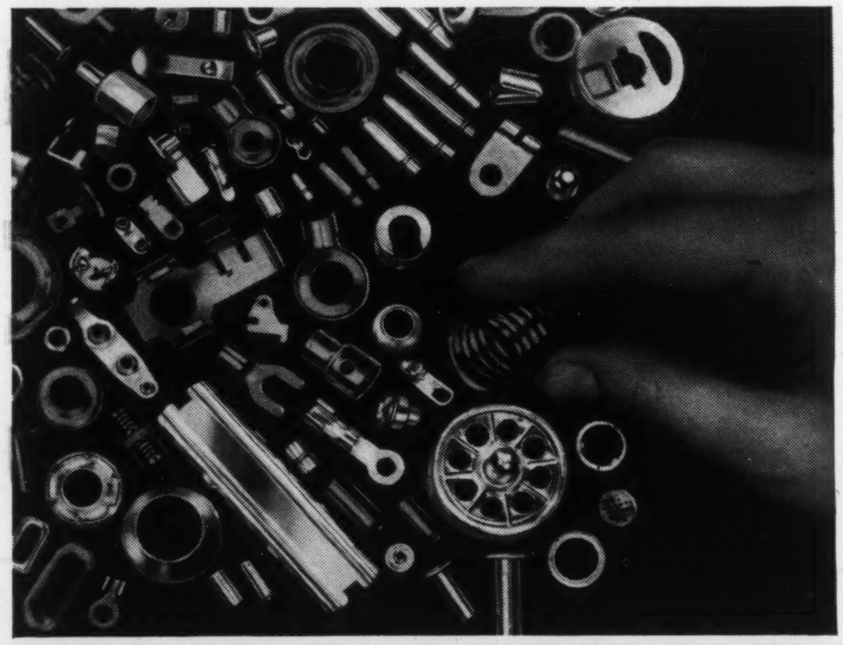
TAKE A FRESH LOOK at the way you are fabricating metal parts. Cost-cutting possibilities are almost unlimited with these Anaconda pre-formed mill products and press products.



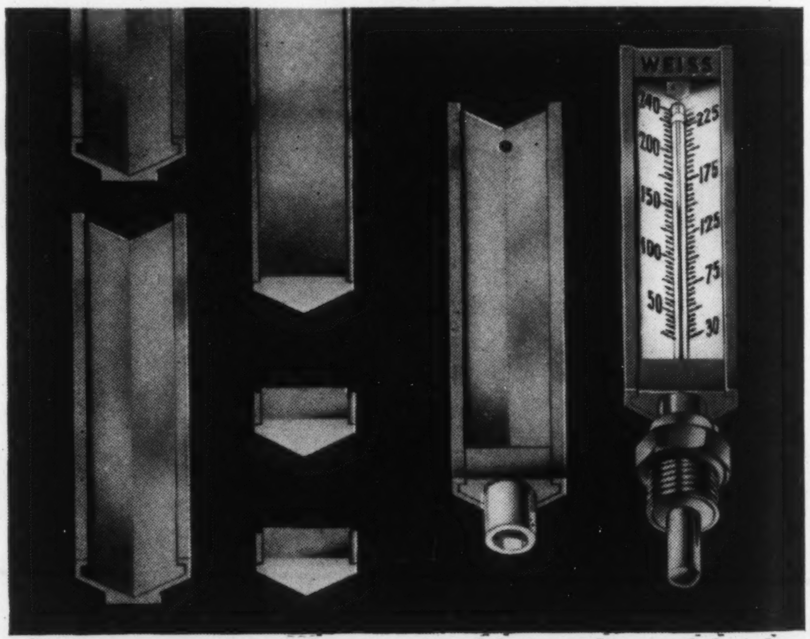
DIE-PRESSED FORGINGS, made of twice-wrought metal, offer superior uniformity, denseness, accuracy. *Savings*: replace more costly built-up assemblies—often are less in first cost than sand castings—require minimum surface machining to size—simplify secondary operations—lower tool cost—lower finishing cost.



SPECIAL-SHAPE TUBES can, as in the case of Electrolux, save several steps in arriving at a finished part. Brass electric-motor brush holder (above) is cut economically from long lengths of tube pre-shaped to accommodate both brush and spring. Uniform accuracy of all dimensions helps provide good brush stability.



MULTIPLE-PLUNGER AND PROGRESSIVE-TOOL-PRESS PRODUCTS are cutting costs throughout industry—often over 50%. Main reasons: The American Brass Company's complete design engineering service, long experience, specialized production equipment, a big selection of stock tools. Metals: copper, copper alloys, nickel, iron, steel, stainless steel, or aluminum.



EXTRUDED SHAPES. Wherever you fabricate from solid rod or bar—or castings—consider savings in machining, tooling and scrap by use of extruded shapes. Albert A. Weiss & Sons substituted two extruded shapes, above, for a sand casting—cut cost of thermometer case 41%, got an additional 30% saving in assembly because of consistently uniform dimensions.

HERE are four immediate approaches to cutting costs. Re-evaluate your designs and fabrication methods with these short cuts to finished products in mind. Wherever you spot a possible saving, send a sample, drawing, or description—with the quantity you need, the metal or properties you require—and ask for a quotation. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ontario. 5853

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Materials in Design Engineering®

formerly Materials & Methods

Selection & use of metals, nonmetallics, forms, finishes

AUGUST 1958
VOL. 48, NO. 2

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They offer sound sections, economical hollow cylinders. Here are the properties of ferrous castings.

Lower Costs with No-Draft Forgings .... *H. Harvey* **94**
Where light weight is important you can save machining time by using zero-draft aluminum forgings.

An Up-To-Date Report on the New Polyethylenes—Part 2 .... *Malcolm W. Riley* **96**
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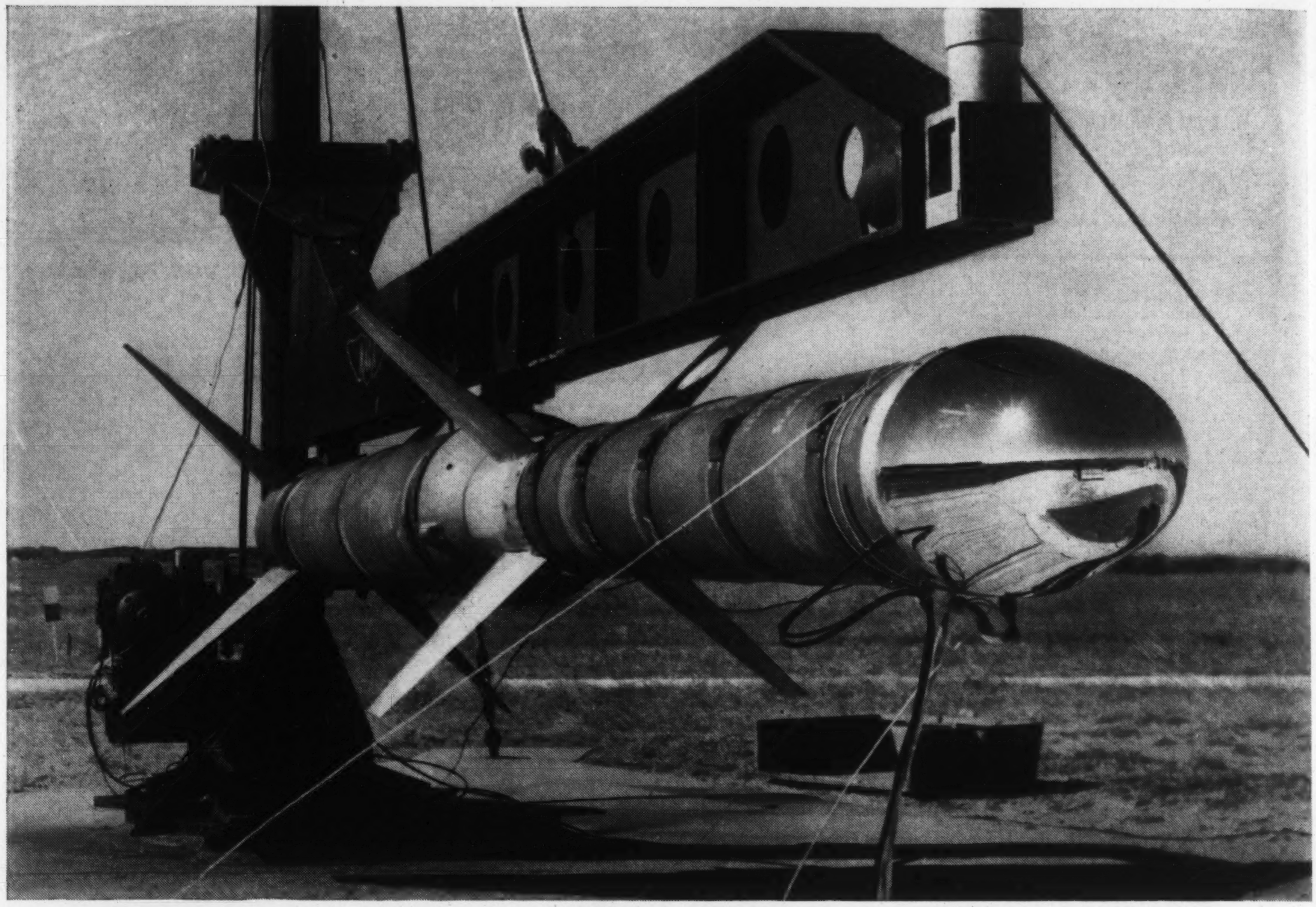
COVER BY HARRY & MARION ZELENKO



EXPERIMENTAL MISSILE is used by NACA researchers to study high temperatures at speeds up to Mach 5. The nose cone is spun Inconel alloy, polished down to a 2 micro-inch finish at the tip. *Photo courtesy of Aviation Week.*

The search to keep a missile's nose from becoming its "Achilles' heel"

Intercontinental ballistic missiles are designed to plunge back into the earth's dense atmosphere at speeds in the neighborhood of Mach 10.

Temperatures in the thin boundary layer of air surrounding it are measured in *thousands of degrees Fahrenheit.*

How do you keep the nose from melting?

A sharp, needle-point nose reduces aerodynamic drag. But it doesn't help dissipate heat. A blunt nose shape does considerably better, even though it causes a high pressure drag, and creates intense heat in the shock wave. One explanation for the good showing of the blunt shape is that heat follows the wave—and just sort of "slides off" the nose.

For experimental purposes, scientists need a nose material that can be spun into a great variety of shapes . . . one that maintains structural integrity far up the temperature scale. And those are among the reasons they often select high-strength, heat-resisting Inconel* nickel-chromium alloy . . .

The National Advisory Committee for Aeronautics, for example, began using Inconel alloy for tests after a several-year-long investigation of materials suitable for use at high Mach numbers and high temperatures.

Of course, much is still to be learned about the mechanics of aerodynamic heating and its applications to the design of hypervelocity aircraft and missiles. But the tests are indicating how the problems can be solved. And advances such as those being made daily by NACA's research are rapidly leading to perfection of "The Ultimate Weapon," the device that may well prevent war among men.

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What's new IN MATERIALS

...AT A GLANCE

THE FIRST ALL-BETA TITANIUM ALLOY, said to have the best formability of any titanium alloy, has been developed. The alloy can be cold headed and welded, and can be heat treated to high strength levels. (More details next month.)

TWO OTHER TITANIUM ALLOYS, BOTH SHEET ALLOYS, have also been developed. One contains 16 vanadium and 2.5% aluminum; the other contains 4 aluminum, 3 molybdenum and 1% vanadium. Both alloys are formable in the soft condition and can be heat treated after forming to high room and elevated temperature strengths. (More details next month.)

CLEAR OR PIGMENTED POLYPROPYLENE YARN is now commercially available. Tentative properties of the yarn include a specific gravity of 0.90, a softening point (without load) of 280 to 300 F, an elongation of 15 to 25%, and a tensile strength, "as is," of 60,000 to 85,000 psi. The yarn is presently being made into rope by a leading U. S. rope manufacturer.

THE FIRST ANNOUNCED COPOLYMER OF ETHYLENE and other monomers, specific composition of which has not been revealed, is now in commercial production. The thermoplastic material is the first of a group of tailor-made polymers designed for long time sustained load bearing and stressed service. Biggest single use will probably be monofilaments for such products as rope; other grades will soon be available for film, wire covering, pipe, blown bottles and paper covering. (More details in a forthcoming issue.)

WEAR RESISTANCE OF METAL PARTS CAN BE IMPROVED by electroplating them with a metallic coating containing finely divided particles of carbides or oxides. For instance, an electrodeposited nickel coating containing particles of silicon carbide has doubled the life of saw blades and certain dies used in forging alloy steels. Coatings being developed include mixtures of tungsten carbide and aluminum oxide with cadmium, silver and copper.

HIGHER TEMPERATURE RECTIFIERS AND TRANSISTORS than presently available is the aim of a study on the properties of three intermetallic compounds previously discussed in this magazine (see M/DE, Mar '58, p 114). The compounds—indium phosphide, gallium arsenide and aluminum antimonide—seem to be the most promising of the III-V compounds for semiconductor devices operating in high temperature and nuclear environments.

A SPEED-UP IN THE FINISHING OF METAL PARTS will probably result from the use of a paint spraying system, now under development, that cleans, phosphatizes and paints within a single unit. The system, somewhat similar in design to a vapor degreaser, will be completely noninflammable and will have no intermediate drying stages.

STRAIN-FREE SYNTHETIC SAPPHIRES 1/4 IN. THICK and 3/4 in. square result from a new synthetic sapphire growing technique that involves dissolving and recrystallizing aluminum oxide from an aqueous solution under high pressures and high temperatures. A synthetic ruby is produced by the process if the aluminum oxide solution is "doped" with small amounts of a chromate. (For information on another synthetic sapphire growing technique, see M/DE, Sept '57, p 161.)

ALUMINUM FOIL CAN NOW BE WELDED IN CONTINUOUS SEAMS by using a newly developed, hand operated ultrasonic welding machine. The welding machine is said to make possible sealed, aluminum foil packages that are airtight and resistant to all penetration except puncture or tearing.

DIPPING, CASTING AND SPRAYING OF A FLUOROELASTOMER is now possible with the introduction of the material in latex form. Potential uses include supported and unsupported films, dipped goods, coated fabrics, tank linings and electrical insulation.

IMPROVED ELECTRICAL GRADE STEEL WIRE has come out of the development of a new continuous process that turns out aluminum-covered steel wire. The process imparts a much thicker aluminum covering to steel wire than conventional methods, and the heavy covering is said to greatly increase electrical conductivity of the wire. Brittle intermetallic compounds which often occur when aluminum is applied to steel have been eliminated in the process.

A PORTLAND CEMENT-BASE MATERIAL is being studied as a possible substitute for wood. Cast into planks and panels, the material can be sawed, nailed and glued like wood. Though having only about half the strength of hard woods, the material is reported to be strong enough for many jobs now done with wood.

Turn to page 123 for more "What's New in Materials"

BRIEFS

Do-It-Yourself Bathtub

A new bathtub made of fiberglass reinforced plastics can be installed easily and quickly by one man because of its light weight. The tub is guaranteed not to warp, bend or break.

Making Carbides Sizzle

A torch for melting materials like tungsten carbide is now commercially available. The device, called a plasma torch, is capable of sustained operation at temperatures of 20,000 F and higher. It is priced from $6000 to $10,000.

A Very Sweet Coating

Scientists have developed a sugar derivative that shows promise as an extender for many types of coatings. The derivative, sucrose acetate isobutyrate, is an extremely viscous, clear liquid.

Stainless Hot Dog Stand

The familiar mustard stained wooden hot dog stand may be a thing of the past with the introduction of a stainless steel cart that is said to be both functional and good-looking. The cart is easy to clean and the stainless steel helps to retain heat and cold, requisites for good hot dogs and soda pop.

Piping Maple Sap

Plastics pipe, spouts and connecting joints (painted bright red so they will not be lost in snow) are being used to transport the sap from thousands of maple trees into one large reservoir. The plastics parts are made of a special surgical-grade polyvinyl chloride compound that is odorless and tasteless.

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This same plastic makes crisper-trays, food containers and tumblers that never turn brittle, never shatter when frozen, and are easily cleaned.

These very qualities of durability recommend GREX for a limitless variety of uses: refrigerator parts that stand up under heavy loads and cold temperatures; sterilizable bottles; canisters and cups that don't break; automotive parts . . . toys . . . furniture drawers. You name it, and we'll show how *this versatile plastic means better products for you.*

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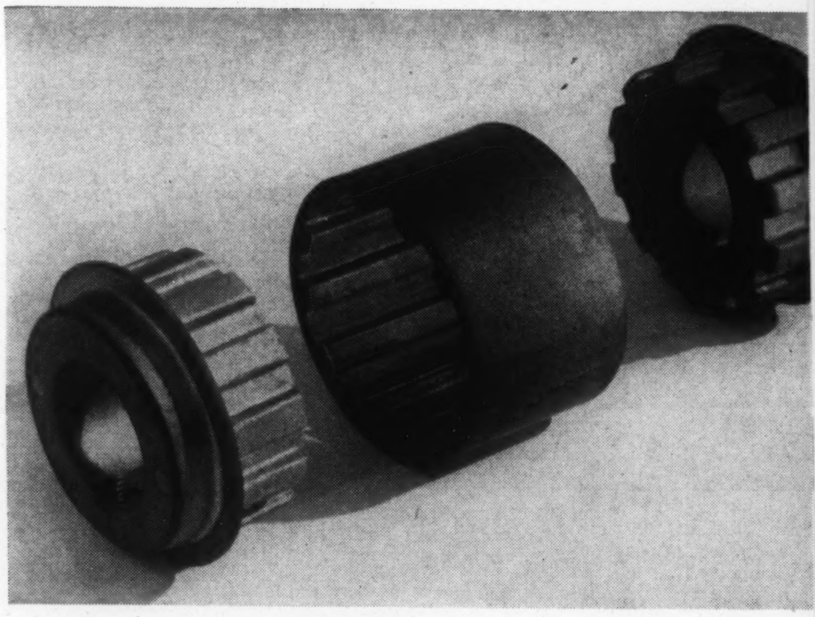
MATERIALS

AT WORK

New
and interesting
applications
of engineering
materials



Flexible coupling uses neoprene

Low cost and good resistance to oil, heat and shock are the reasons for the selection of neoprene for the main element of a new flexible coupling (see top photo) designed to absorb load pulsations and shocks in power transmission systems.

The coupling consists of a neoprene sleeve with axially-molded teeth and two metal end fittings with grooves that mate with the teeth of the sleeve (see bottom photo). For small couplings, neoprene and die cast zinc end fittings are used; for larger couplings, the neoprene sleeves are reinforced with textile fibers (usually Fortisan) and iron or steel powder parts are used for the end fittings. Overall length of the coupling can be easily varied by merely changing the length of the neoprene sleeve.

According to U.S. Rubber Co., the couplings are designed to handle loads up to 40 hp at 1750 rpm or torque loads up to 1440 in-lb. Because there is no metal-to-metal contact, the coupling never requires lubrication.

Aluminum auto engine reduces weight, cost

The experimental automobile engine shown in the accompanying photo is believed to be the first ever made of aluminum in this country. Although its outward appearance resembles that of conventional cast iron V-8 engines, the new unit weighs about 30% less and is said to have a higher compression ratio.

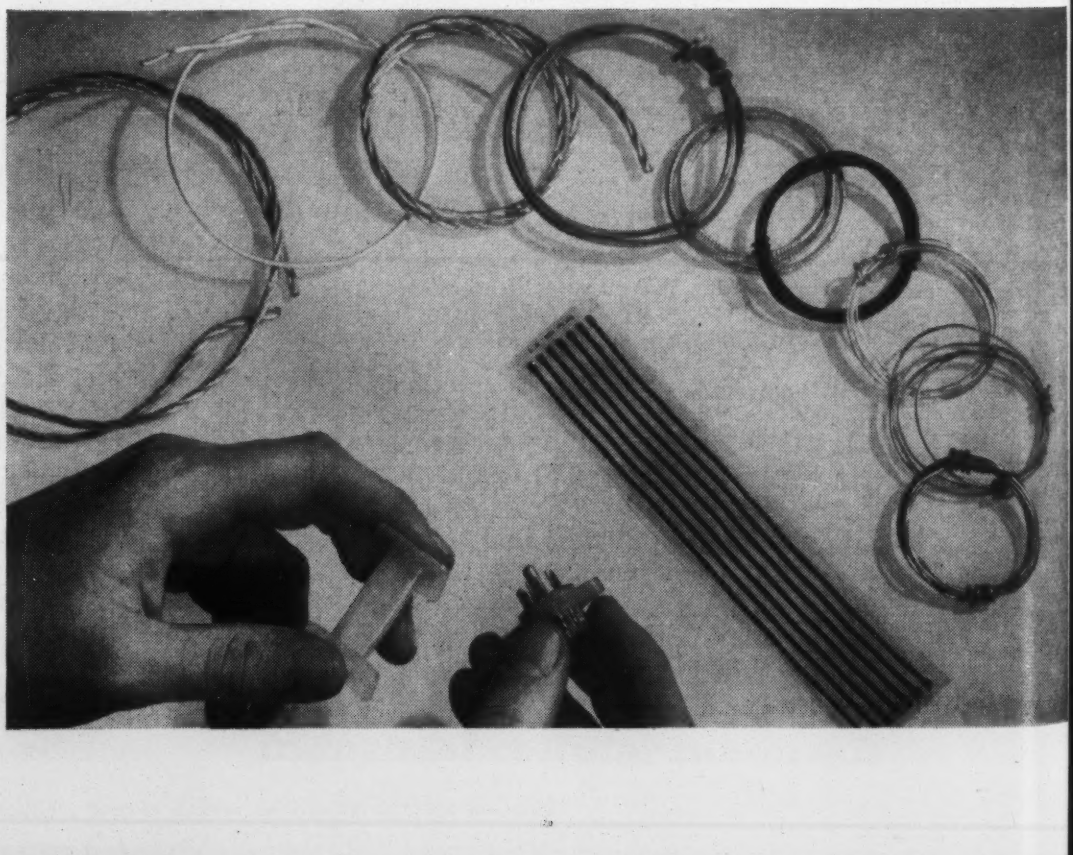
Thus far three aluminum engines have been built and successfully tested both in the laboratory and on the road. According to General Motors Corp., widespread use of aluminum in future engines depends on the ". . . successful development of castable, wear resistant aluminum alloys or dependable coatings which may be economically and simply applied and inspected."

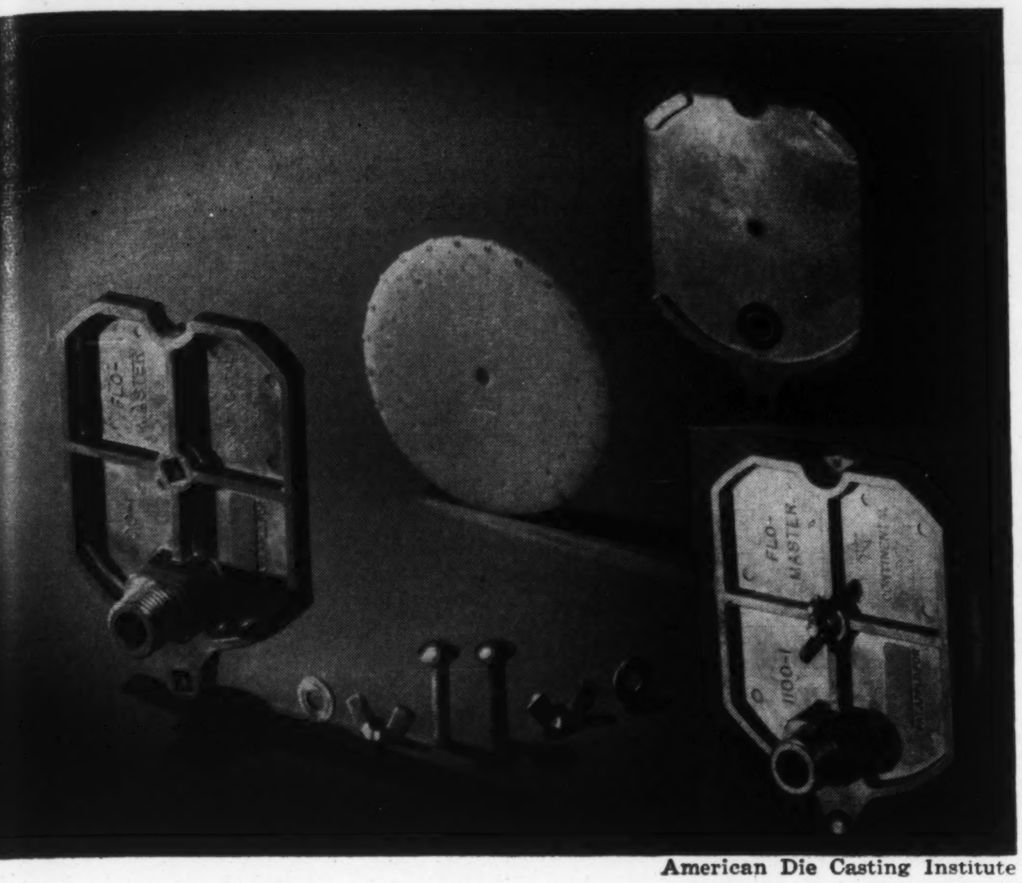
The primary advantage of aluminum engines is obviously lighter weight; however, aluminum is much easier to work than cast iron and the ultimate objective is to build these lightweight engines ". . . at less cost but with better performance than cast iron engines."

New fluorocarbon has many potential uses

The coil forms, tube sockets, wire insulation and sheet shown in the photo at right are some of the products capable of being made from Teflon 100-X (fluorinated ethylene propylene), Du Pont's newest fluorocarbon plastic.

According to Du Pont, the material 1) possesses excellent heat, electrical and chemical resistance at temperatures up to 400 F; 2) has no known solvent; 3) is completely moisture resistant; 4) has an extremely low coefficient of friction; and 5) can be easily molded or extruded into a variety of products in addition to the ones shown here.





American Die Casting Institute

Nylon + aluminum = efficient metering unit

By sandwiching a perforated nylon disk between two identical aluminum die castings, B.C.G. Mfg. Co. has come up with a new metering device that is said to be more efficient and less subject to failure than previous models.

Here's how it works: 24 different sized, numbered holes are placed near the outer edge of the nylon disk (see photo). By merely loosening two wing nuts, the disk can be rotated to bring the desired orifice opposite the cast inlet and outlet projections on the aluminum castings. Once the meter is set for the correct orifice it requires no further adjustment, and there are no pressure gages, diaphragms or springs to cause failure.

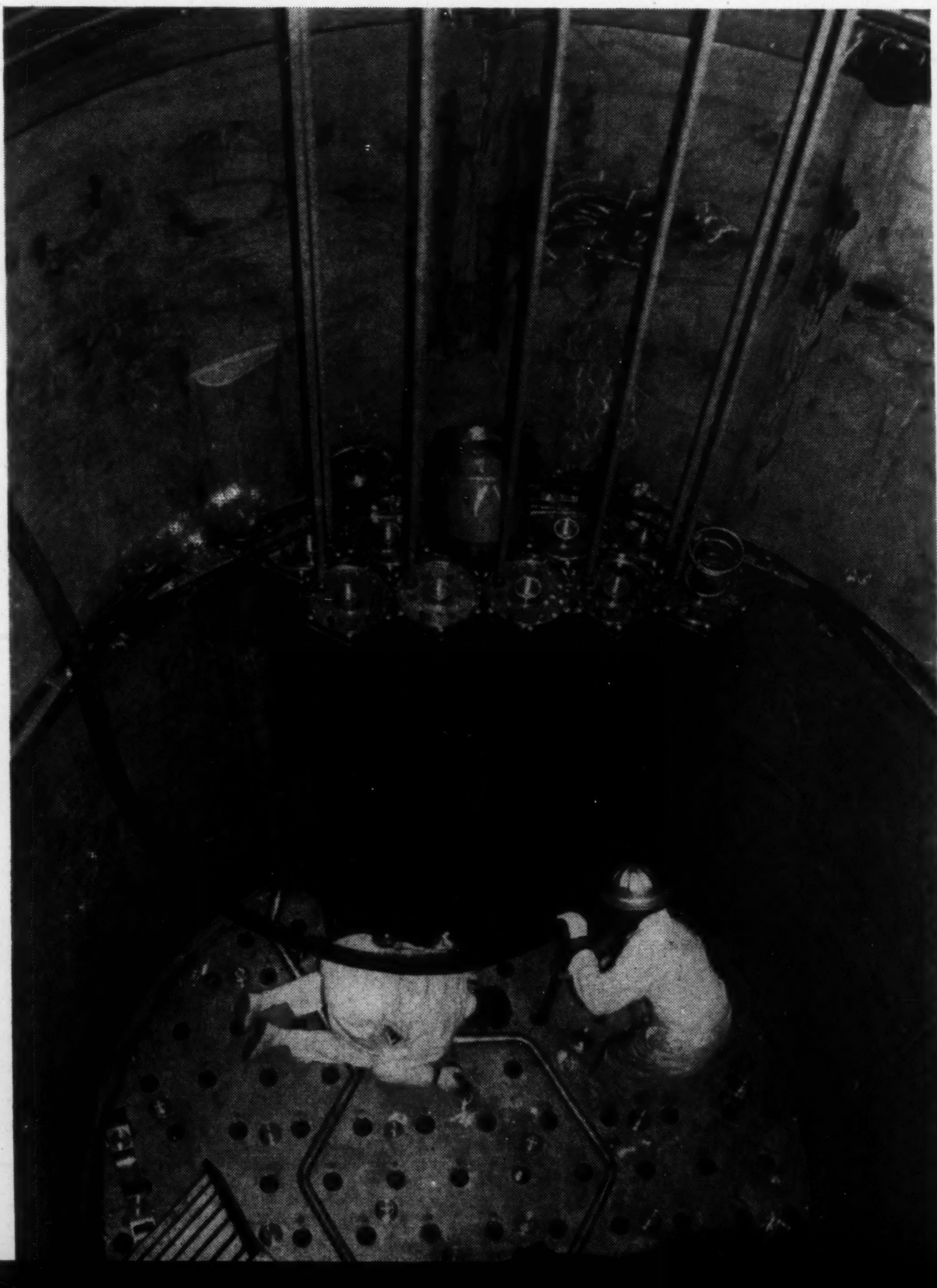
Aluminum was selected because it is lightweight and easy to fabricate; nylon was selected because it is strong and self-lubricating.

conium-encased graphite kes neutrons in reactor

gh purity graphite rods sealed in zirconium cans performing the vital function of reducing the speed eutrons from 6000 miles per sec to 1 mile per sec e reactor core tank of the first non-military nuclear tor (see photo at right). The graphite is essential use neutrons emitted from a split uranium atom be slowed down or fission will not be properly ained.

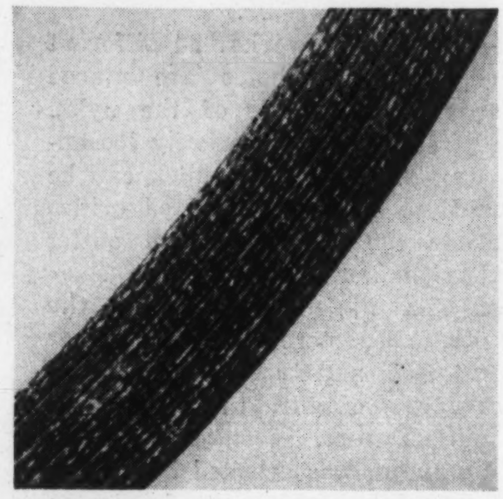
cording to National Carbon Co., Div. of Union ide Corp., graphite is ideal for this application use it has no melting point (it sublimes at approxi-ly 6400 F) and can be easily machined into intricate es. The zirconium cans are necessary to prevent the d sodium used as a cooling medium from being rbed by the graphite.

MATERIALS
AT WORK

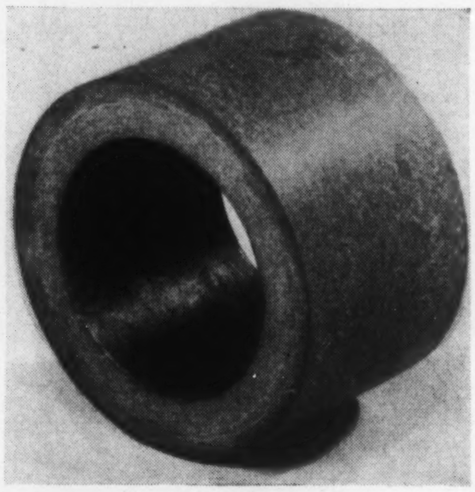


Asbestos materials now used in autos for...

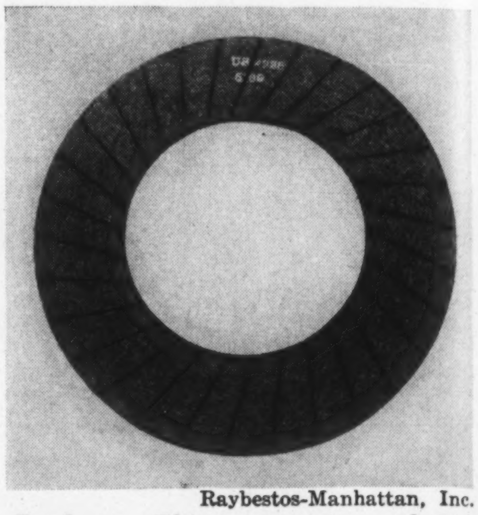
Within the past few years asbestos friction materials have found considerable acceptance in automotive applications. There are several reasons for this: they have excellent engagement characteristics (due to good flexibility and resiliency), high coefficient of friction, and good strength, and they are relatively inexpensive. Shown here are three of the latest automotive applications of both woven and nonwoven asbestos friction materials. (For further details on fabrication, properties and design factors, see M/DE, Oct '57, p 130.)



***Linings**—Ranging in thickness from 0.040 to 0.125 in., this woven asbestos lining for automatic transmissions is among the thinnest ever produced—yet it provides high strength, excellent flexibility and good friction in oil.*

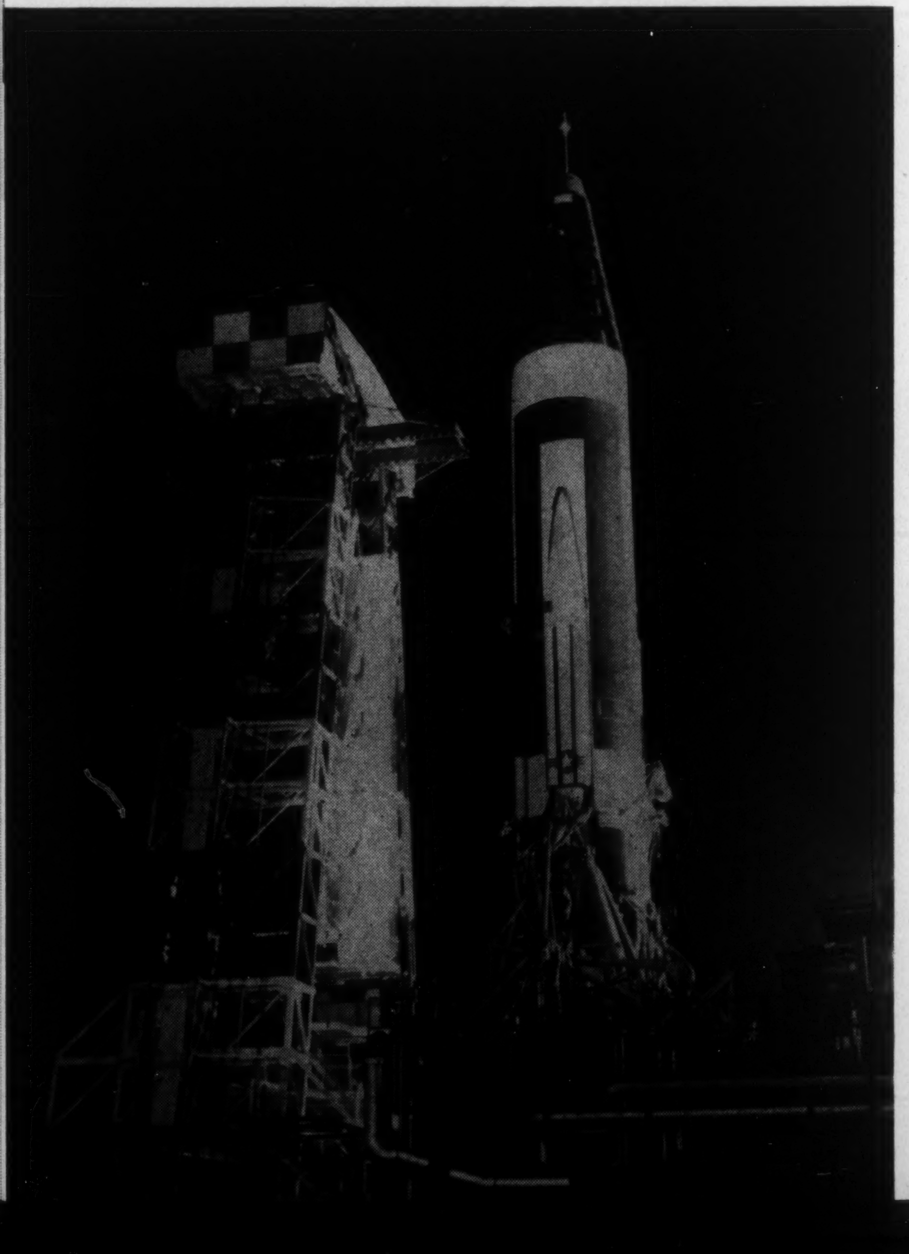


***Bushings**—Longer life at less cost than conventional parts is claimed for this nonwoven asbestos felt engine mounting bushing. The part measures 3 in. o.d., 2 in. i.d. and 1¾ in. long.*



Raybestos-Manhattan, Inc.

***Facings**—This nonwoven asbestos felt clutch facing material is said to have extremely high centrifugal burst strength in dry applications, good durability and smooth engagement.*



Atlas missile almost all stainless

With the successful firing of the U.S. Air Force's Atlas intercontinental ballistic missile, stainless steel has added to its bid for extensive use in high speed aircraft, missiles and rockets. Latest released information indicates that except for the warhead the entire protective skin of the Atlas (see photo at left) is made of stainless steel sheet.

According to the Committee of Stainless Steel Producers, American Iron and Steel Institute, stainless was specified for the Atlas because its combination of good tensile strength and high temperature and corrosion resistance allows the use of extremely thin sheet to achieve light weight. In addition, the stainless skin serves as the walls of the propellant tanks which comprise nearly the entire length of the missile.

(continued on p 170)

MORE MATERIALS AT WORK

Drink mixer uses new molding method 170

Magnesium-thorium used in Bomarc missile 172

Molded vinyl plastisol for traffic marker 174

Fused silica crucibles 176

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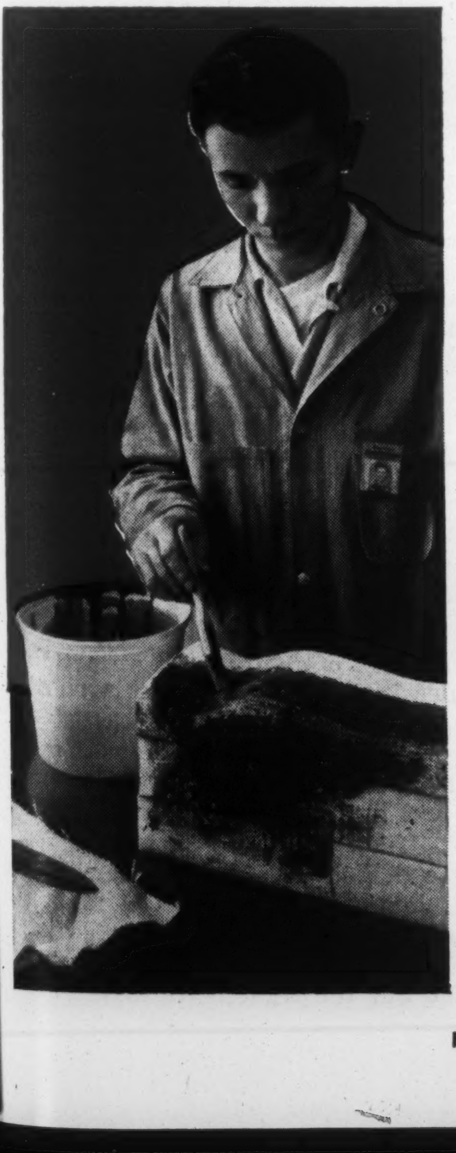

"In producing experimental missile components, we need a fast, foolproof and economical method of checking accuracy. And Reichhold EPOTUF epoxy resins have played a major role in our development of just such checking units."

Speaking is Mr. Bob Thompson, Plastics Project Leader, Experimental Manufacturing Department, Avco Research and Advanced Development Division, Lawrence, Massachusetts.

Avco's experimental work on the Titan ICBM nose cone is a vital, high priority project. Complex parts must meet exact tolerances. The slightest imperfection might cause failure.

For instance, one length of pipe for the nose cone twists and turns sixteen different times in its 34-inch length. To test the accuracy of each bend, AVCO has developed tools such as you see above made of RCI epoxy resins and RCI polyurethane foam. Such devices can be made quickly and inexpensively, and solve one of Avco's toughest testing jobs.

"Furthermore, another benefit we gain in dealing with RCI is invaluable technical aid," Mr. Thompson stated. "Also we have never experienced any delays in delivery . . . and we absolutely need this kind of service."

Perhaps dependable, versatile RCI EPOTUF epoxy resins or RCI POLYTOOL plastic tooling compounds will improve *your* application. Write RCI for details.

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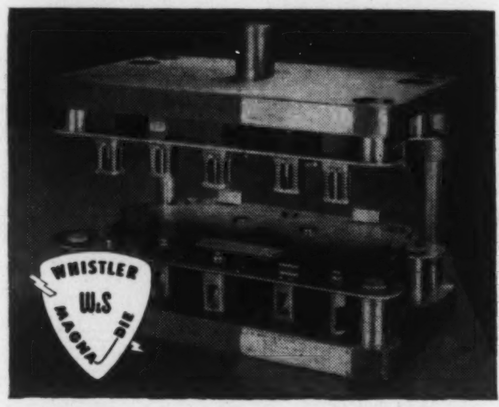

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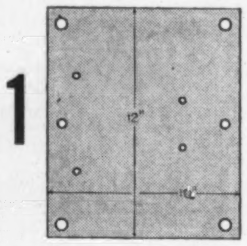

Custom Die $925*
Orig. Magna-Die ... 819
SAVINGS $106

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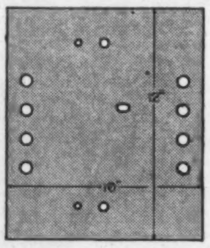

Custom Die..... $1100*
Magna-Die Parts. 390
SAVINGS...... $710

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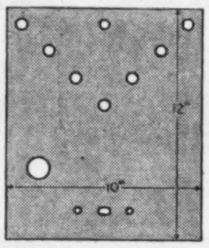

Custom Die..... $1040*
Magna-Die Parts. 247
SAVINGS...... $793

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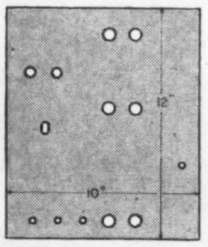

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Letters to the editor

Glass mold design

To the Editor:

I have subscribed to your publication for almost four years and have a very high opinion of its ability to keep me informed on new materials and developments.

I recently changed my engineering field from automotive carburation to the mold phase of glass container manufacture. Has your magazine run any articles on glass properties or metal applications to glass mold design? Would you consider this subject as a future article possibility?

CLARENCE S. MATTHEWS
Thatcher Glass Mfg. Co., Inc.
Horseheads, N. Y.

Our manual, "How to Select and Specify Glass," Nov '56, is the most comprehensive article on glass that we have published. Our articles are not directed to molders and fabricators and therefore we would not ordinarily publish articles concerned specifically with metal applications to glass mold design.

Cadmium plating

To the Editor:

This is in reference to your abstract of a technical paper relating to embrittlement from cadmium plating, M/DE, Apr '58.

The statement on p 218 that "plating voltage appears to be a function of bath composition" can be extended. Other factors which also affect plating voltage are: temperature of bath and work, preplating treatment, solution agitation, current densities, polarization and depolarization, ratio of anode-to-cathode area, anode-to-cathode spacing, and the specific nature of the anodes and cathodes.

EARL J. MONTIE
Chemist
Briggs & Stratton Corp.
Milwaukee, Wis.

Stainless steel data

To the Editor:

In your May '58 issue, p 104, there is an article entitled "New Stainless Steel to Beat Heat Barrier." Armco Steel Corp. has a 17-7PH stainless steel which is similar to the English 16-6PH alloy. Your readers might be interested in the results of some experimental work we have done with the Armco alloy.

Eight holes were drilled with a jig borer, four on a 15-in. bolt circle and four on a 7½-in. bolt circle, in an annealed (B80-88) 3/16-in. plate. After heat treating at 1400 F for 1½ hr the plate hardness increased to C30 but the eight holes moved *out*

PRODUCT-DESIGN MEMOS FROM DUREZ

Insulative molding compounds

Corrosion-resistant polyester
Low-cost control knobs

Official U. S. Navy photo

But what if it rains?

From time immemorial, weather has upset the military plans of men. In colonial days, wet gunpowder could lose a skirmish. Today, one moisture-affected part can nullify months of costly labor on a new missile.

This helps to explain the increasing pressure on moisture-resistant insulations for electronic parts that must not fail. It explains, too, the growing interest in a relatively new Durez molding material, *diallyl phthalate.*

This is the *only* plastic that retains its high insulation values over extended periods at relative humidities above 90%.

Its arc resistance, as measured by ASTM D495 (Method A or B), can be consistently reproduced.

It does not corrode metal contact points.

Because it is a thermosetting material, it provides virtual freedom from cold flow and creep.

You can get this material from us as an orlon-filled granular blue or green molding compound with plasticity values of 10, 12, or 16 by ASTM D731. It is designed to meet the requirements of Mil-M-18794, Type SDI-5.

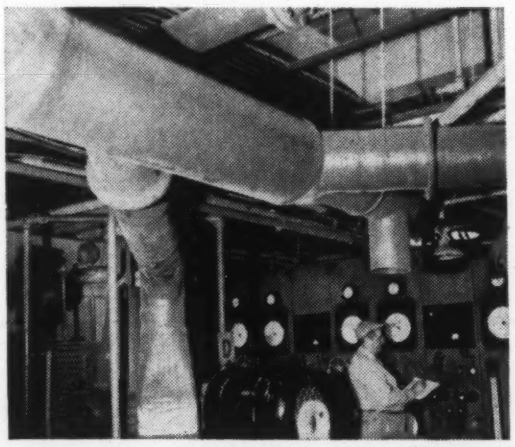
For a data sheet detailing properties of the compound, and of molded material, check the coupon.

Hetron® ducts outlast metal

Perhaps you've been thinking of Hetron mainly as a *fire-retardant* polyester material. It's true you get outstanding fire retardance with Hetron. But don't overlook its *corrosion resistance,* which is equally impressive in equipment such as this glass-reinforced ductwork manufactured by duVerre, Inc.

Venting corrosive fumes from a chemical reactor, aluminum ducts failed in 11 months. Ducts made of Hetron 92 replaced them—and have gone 17 months without a sign of deterioration.

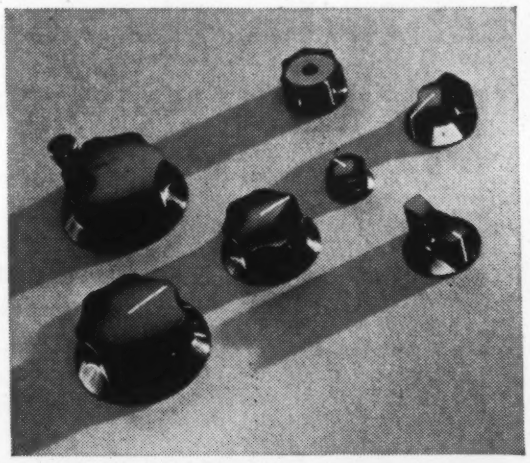
In another plant, Hetron 92 replaces rubber-lined steel ductwork which lasted less than a year under the corrosive bite of wet chlorine. The Hetron ductwork, in service four years, has required no maintenance and is as sound as the day it was installed.



duVerre, Inc.

Because it is self-extinguishing, you can safely specify Hetron in many places where a conventional polyester won't do. Fire retardance is *inherent*—does not depend on additives that might dilute corrosion resistance.

Are you taking full advantage of Hetron's unique qualities? A check mark on the coupon will bring you an illustrated bulletin outlining properties and uses of the versatile Hetron resin family.



Ready-tooled knobs

Why tool up for a standard item like a control knob, when you can buy general-purpose knobs like these—probably at a good saving?

Many custom molders can supply knobs in Durez phenolic, from stock tooling, to fit most standard mountings. You can have them hot-stamped with numbers or characters; equipped with special motifs.

Styled as a family, they blend smoothly with modern equipment lines; wipe clean without dulling; and stand up to heat, dampness, and corrosive atmospheres. For further information, consult your molder.

For more information on Durez materials mentioned above, check here:

☐ Diallyl phthalate, Durez 16694

☐ Hetron polyester resins (bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

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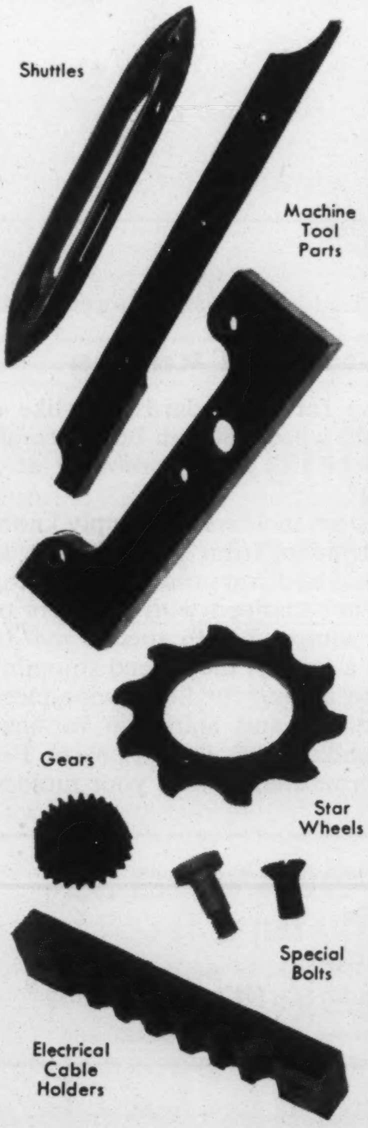

All of the parts shown here were made of high-pressure plastic laminates. In every case the selection of this material substantially improved product life and performance . . . or, made a new application possible.

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Letters to the editor

from the center 0.0044 in. After the second heat treat at 1050 F for ½ hr, the plate hardness increased to C40-47, but the holes moved *in* 0.0009 in. After heating to 1050 F for 48 hr for Malcomizing, the plate hardness dropped to C32 and these holes moved *in* another 0.0008 in. This material could be drilled after heat treating at 1400 F provided the hardness was not over C30.

From the above it might be suspected that the English 16-6PH alloy has similar characteristics. The movement of the material during heat treatment and loss in hardness should be known if it is going to be used for aircraft.

G. H. Bohn
Linde Co.
Div. of Union Carbide Corp.
Tonawanda, N. Y.

Cupro-nickel error

To the Editor:

I have read with a great deal of interest your article on cupro-nickels, M/DE, May '58. I would like to call your attention to the fact that the elongation and reduction of area data for the 70-30 copper-nickel alloy, given in Table 3, p 117, were values obtained at maximum load. The true ductility values should be stated.

William D. Jenkins
Metallurgist
National Bureau of Standards
U. S. Dept. of Commerce
Washington 25, D. C.

The correct values are: Elong (2 in.), %, 52, 56, 58 and 62 (for temperatures of 68, –108, –220 and –320 F respectively); Red. of Area, %, 80 for room temperature, 78 for lower temperatures.

Fillers vs resins

To the Editor:

We manufacture Shelfil industrial flour which is a finely ground walnut shell used as a filler for adhesives and plastics. Can you tell us where we can secure additional information about the uses of fillers with various resins and the properties which different fillers add in the manufacture of different types of plastics?

H. J. Dugdale
Secretary-Treasurer
Dugdale & Sons, Inc.
Cornelius, Ore.

We suggest contacting Society of the Plastics Industry, Inc., 250 Park Ave., New York, N. Y. or the Manufacturing Chemists' Assn., Inc., 625 Eye St., N.W., Washington 6, D. C.

Janney Cylinder Co.

Pump parts *centrifugally cast from stainless steel (ACI CA-40).*

Why and where to use

Centrifugal Castings

PART 1 • FERROUS METALS

by John L. Everhart, *Technical Editor, Materials in Design Engineering*

Centrifugally cast parts are serving in many applications requiring hollow cylindrical forms or sections with exceptional soundness.

■ Centrifugal castings can be produced economically and with excellent soundness. They are used in the automotive, aviation, chemical and process industries for a variety of parts having a hollow, cylindrical form or for sections or segments obtainable from such a form. Although there are three modifications of centrifugal castings (see box), only true centrifugal casting is covered in this article.

The nature of the centrifugal casting process assures a dense homogeneous cast structure free from porosity. Because the metal solidifies in a spinning mold under centrifugal force, the metal tends to be forced against the mold wall while impurities, such as sand, slag and gases, are forced toward the inside of the tube. Another advantage of centrifugal casting is that recovery can run as high as 90% of the metal poured.

Centrifugal castings are produced of many different ferrous and nonferrous metals. Castings made of the ferrous metals—cast irons, carbon and low alloy steels, high alloy steels, and duplex metals—will be covered in this article. A second article, to appear next month, will cover nonferrous centrifugal castings.

Mechanical properties

Regardless of alloy content, the tensile properties of irons cast centrifugally are reported to be higher than those of static castings produced from the same heat. Hydrostatic tests of cylinder liners produced by both methods show that centrifugally cast liners withstand about 20% more pressure than statically cast liners.

Properties of some steels are given in the accompanying table. These specific alloys were selected from the literature because the properties were determined on samples cut from the centrifugal castings, not on separately cast test bars. Good strength and excellent ductility are achieved in these castings.

Three Centrifugal Casting Methods

There are three modifications of centrifugal casting: 1) true centrifugal casting, 2) semi-centrifugal casting, and 3) centrifuging. This article is limited to a discussion of true centrifugal casting, although a few parts produced by semi-centrifugal casting are mentioned.

True centrifugal casting is used for the production of cylindrical parts. The mold is rotated, usually in a horizontal plane, and the molten metal is held against the wall by centrifugal force until it solidifies.

Semi-centrifugal casting is used for disk and wheel shaped parts. The mold is spun on a vertical axis, the metal is introduced at the center of the mold and centrifugal force throws the metal to the periphery.

Centrifuging is used to produce irregular-shaped pieces. The method differs from static casting only in that the mold is rotated. Mold cavities are fastened at the periphery of a revolving turntable, the metal is introduced at the center and thrown into the molds through radial ingates.

Freedom from directionality is one of the advantages that centrifugal castings have over forgings. Properties obtained on longitudinal and tangential specimens of several of the stainless grades shown in the table are substantially equal.

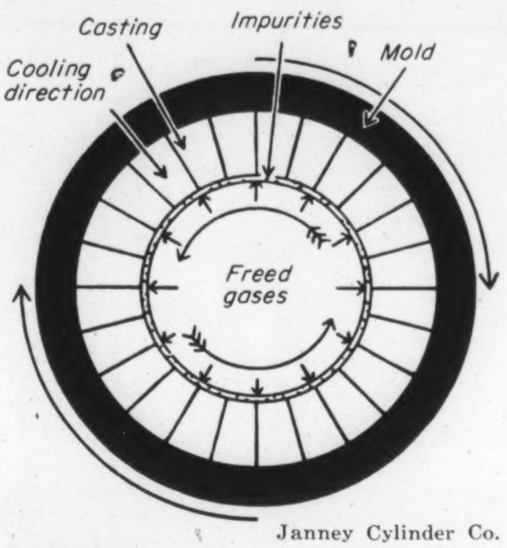
Shapes, sizes, tolerances

The external contours of centrifugal castings are not limited to circular forms. The contours can be elliptical, hexagonal or fluted, for example. However, the nature of the true centrifugal casting process limits the bore to a circular cross-section.

Iron and steel centrifugally cast tubes and cylinders are produced commercially with diameters ranging from 1⅛ to 50 in., wall thicknesses of ¼ to 4 in., and in lengths up to 50 ft. Generally it is impractical to produce castings with the o.d./i.d. ratio greater than about 4 to 1. The upper limit in size is governed by the cost of the massive equipment required to produce heavy castings.

As-cast tolerances for centrifugal castings are about the same as those for static castings. For example, tolerances on the outside diameter of centrifugally cast gray iron pipe range from ±0.06 in. for 3 in. dia. to ±0.12 in. for 48 in. dia. Inside diameter tolerances are greater, because they depend not only on the mold diameter, but also on the quantity of metal cast; the latter varies from one casting to another. These tolerances are generally about 50% greater than those on outside diameters. Casting tolerances depend to some extent also on the shrinkage allowance for the metal being cast.

The figures given above apply to castings to be used in the unmachined state. For castings requiring machining, it is customary to allow 3/32 to 1/8 in. on small castings and up to ¼ in. on larger castings. If the end use requires a sliding fit, broader tolerances are generally specified to permit additional machining on the inside surface.



Janney Cylinder Co.

Spinning mold *used in centrifugal casting shown by schematic drawing.*

Cast irons

Large tonnages of gray iron are cast centrifugally. The relatively low pouring temperatures and good fluidity of the common grades make them readily adaptable to the process. Various alloy grades that yield pearlitic, acicular and chill irons are also used. In addition, specialty iron alloys such as Ni-Hard and Ni-Resist have been cast successfully.

One of the earliest applications of gray iron centrifugal castings was soil pipe. Commercially, pipe is produced in sizes ranging from 2 to 6 in. i.d. by 5 ft long. Other lengths can be supplied.

Millions of piston rings have been cut from centrifugally cast iron tube. To reduce costs, these rings are not heat treated and, therefore, must be free from chill and have good wear properties as cast. Selection of an iron that contains properly balanced ferrite and pearlite forming elements is required.

Heavy-wall cast iron cylinders are used in production of bearings. The castings are cut to length, machined on inside and outside surfaces and split. They are then babbited on the inner surface with a thin layer of bearing metal. The important property of the metal for this application is soundness; porosity on the inner surface would prevent successful babbiting. Parts produced from gray iron are also used for process industry piping and rolls, gears and flywheels.

Automotive cylinder sleeve castings produced from an alloy cast iron containing chromium, copper, nickel and molybdenum are said to have excellent wear properties and long service life. Alloy cast irons are also used for liners in sub-surface oil pumping units, dryer cylinders in the printing industry, steel mill conveyor rolls, table rolls for hot strip steel mills, Fourdrinier wire cloth warp rolls and mandrels.

Meehanite castings are used for gasoline engine cylinder liners, run-out table rolls for hot strip steel mills, lathe spindles, hydraulic cylinders for pressures up to 3000 psi, oil field pump cylinders. Centrifugally cast Meehanite bars are also produced for machining into various parts.

Ni-Hard centrifugally cast tubing is used in the glass and ceramic industry for air conveying of frit materials. These materials, moving at speeds up to 100 miles per hr, are highly abrasive. In this application Ni-Hard lasts much longer than rubber-lined steel piping.

Ni-Resist is used for pump liners and dry liners for truck and diesel engine cylinders. Bar stock is supplied for fabricating into various parts.

Carbon and low alloy steels

Centrifugal castings are produced from carbon steels having carbon contents ranging from 0.05 to 0.90%. Practically all of the AISI standard low alloy grades have also been cast.

Hollow ship shafting, produced from a 0.35% carbon steel by centrifugal casting, has been used as part of the main propulsion system in destroyer-escorts, tugs, coast guard cutters and cargo vessels. This development resulted from tests made during World War II when forged shafting was in short supply. Some other successful applications of carbon steel centrifugally cast tubing are bearing backs, cams, engraving rolls, generator and motor frames, hydraulic cylinders and rams.

Gas turbine annular parts operating at room temperature are being produced by centrifugally

Centrifugal Castings Have These Advantages and Disadvantages . . .

Compared to Static Castings

ADVANTAGES

Better soundness and cleanliness

Lower scrap losses

Greater adaptability to quantity production

Freedom from centerline shrinkage

Inspection tends to be simpler because defects are generally on surface

DISADVANTAGES

Limited in shape and somewhat limited in size

Less economical in small quantity production

Equipment more expensive

Compared to Forgings

ADVANTAGES

Closer dimensional tolerances can be held, thus reducing machining

Parts are free from directional properties

Alloys difficult to forge can be cast satisfactorily

Equipment less expensive

DISADVANTAGES

Forgings generally have greater ductility in longitudinal direction

. . . These Properties

Nominal Composition, %	Heat Treatment	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elong (2 in.), %	Red. of Area, %	Impact Strength, ft-lb	Brinnell Hardness	Source
CARBON STEEL C 0.16, Mn 0.51, Si 0.46, P 0.026, S 0.029	Norm. and temp	68	40	24	32	—	—	Rybka
C 0.35, Mn 1.10, P 0.05, S 0.05	Ann. at 1050 F	75	44	27	45	—	—	Moore and Mackay
ALLOY STEELS C 0.40, Mn 0.8, Si 0.6, Cr 1.0, Mo 0.2	OQ from 1600 F, temp at 1290 F	105	93	26	51	—	C19[b]	Samuels and Schuh
	OQ from 1600 F, temp at 1150 F	138	123	16	40	—	C28[b]	
	OQ from 1600 F, temp at 950 F	175	164	16	29	—	C37[b]	
C 0.27, Mn 0.67, Si 0.27, Ni 1.27, Cr 0.73, Mn 0.29	OQ from 1625 F, temp at 1100 F	136	121	17	53	53[c]	—	Samuels and Schuh
	OQ from 1625 F, temp at 1060 F	144	132	14	46	44[c]	—	
C 0.3, Cr 1.5, Ni 2.0, Mo 0.5	—	136	116[d]	17	42	60[e]	—	Taylor and Armita
STAINLESS STEELS C 0.10, Cr 12.5	Norm. and temp, Long	101	83[f]	23	63	26[g]	225	Felt
	Tang	108	88[f]	24	60	26[g]	230	
Cr 18, Ni 8	As cast	78	34	52	48	—	—	Samuels and Schuh
	WQ from 1900 F	76	34	64	70	—	—	
Cr 19, Ni 95, Mo 2.5, C 0.07	Water quenched, Long	76	40[f]	60	—	68[g]	156	Felt
	Tang	78	44[f]	56	—	64[g]	156	
Cr 19, Ni 10, Cb 0.9 C 0.07	Water quenched, Long	79	40[f]	47	—	26[g]	156	Felt
	Tang	78	40[f]	46	—	25[g]	156	
Cr 25, Ni 12	As cast	87	46	37	45	—	—	Samuels and Schuh
	WQ from 1900 F	84	49	56	68	—	—	

[a] Properties determined on samples cut from castings.
[b] Rockwell.
[c] Charpy at —40 F.
[d] 0.1% Proof stress.
[e] Izod.
[f] 0.2% yield strength.
[g] Charpy at room temp.

casting a steel containing 0.3 carbon, 1.5 chromium, 2 nickel and 0.5% molybdenum. Centrifugally cast AMS 5345 chromium-molybdenum steel has been used as a replacement for forged aircraft cylinder barrels. The centrifugally cast barrels were more economical than the forgings and also had higher resistance to internal pressure. Other uses of low alloy tubing include bushings, gear hubs and jet engine parts.

Small diameter centrifugally cast tubing in the usual carbon steel grades is not competitive in price with mechanical tubing having normal wall thicknesses. However, centrifugally cast tubing is less expensive than statically cast material.

High alloy steels

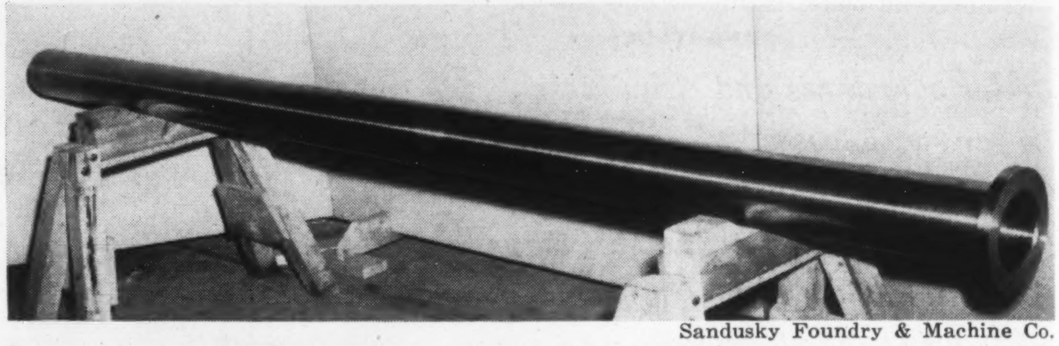
Most of the AISI stainless and heat resisting grades can be cast centrifugally. A particular advantage of the process is its use in producing tubes and cylinders from alloy compositions that are difficult to pierce and to forge or roll.

The excellent ductility resulting in the stainless alloys from centrifugal casting makes it possible to reduce the rough cast tubes to smaller diameter tubing by hot or cold working methods. For example, billets of 18-8 stainless steel, 4½ in. o.d. by ⅝ in. wall, have been reduced to 27 gage capillary tubing without difficulty.

Type 420 stainless steel centrifugal castings are used for shaft sleeves, casings, impeller rings and bushings in centrifugal pumps, for liners in reciprocating and rotary pumps and for steam chamber liners for drop forge hammers. The 18-8 stainless grade is used for shaft sleeves in centrifugal high pressure boiler feed pumps and pipe lines. Rings for jet engine parts for elevated temperature service are centrifugally cast from various high alloy grades including 18 chromium-8 nickel-1% columbium and 25 chromium-12 nickel-3% tungsten.

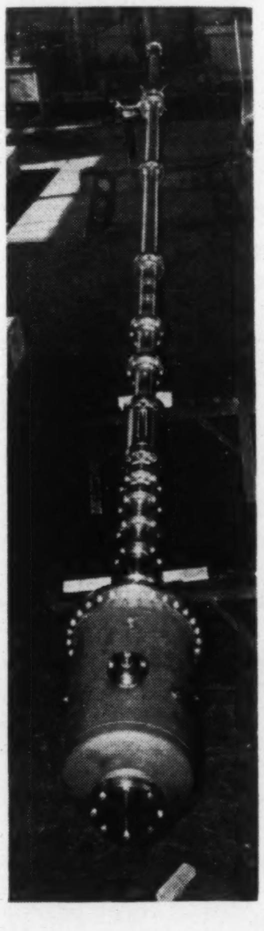
Large diameter 25 chromium–20% nickel stainless steel retorts for chemical service are made by centrifugally casting tube sections 35 in. o.d. by 32 in. i.d. by 12 ft long, welding two of these sections together and completing the vessel by welding statically cast end sections to the assembly. These assembled retorts withstand hydrostatic tests at 3000 psi.

Centrifugally cast parts have these defense uses . . .



Sandusky Foundry & Machine Co.

Submarine induction mast *produced from 20 chromium—13 nickel—2.5% molybdenum steel (Type CF3M) for corrosion resistance to sea water and resistance to deflective stresses.*



Missile design shock tube *designed to simulate temperatures and pressures encountered by a long range ballistic missile as it plunges from space into the earth's atmosphere. Fabricated from centrifugally cast stainless steel tubes, this shock tube is over 44 ft long. It operates at 2300 psi.* (Electric Steel Foundry Co.)

Jet engine ring *produced from chromium - molybdenum - vanadium steel by centrifugal casting with holes cast to size and accurately located to require no machining.*

Lebanon Steel Foundry

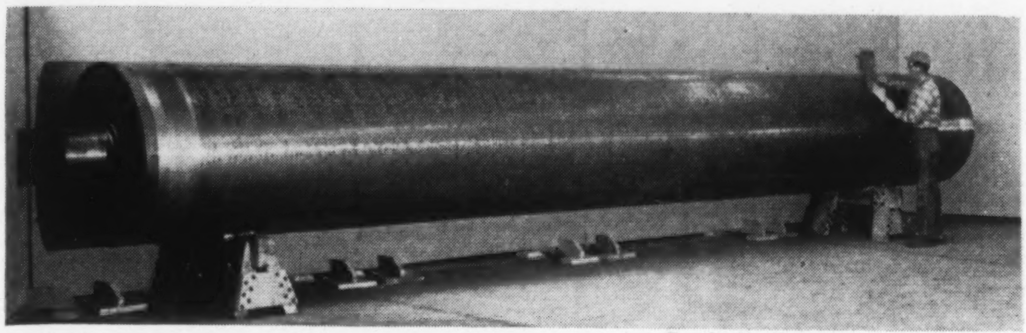
Other applications for stainless and heat resisting steels are retorts for magnesium reduction (28 chromium-20% nickel), pump cylinders (30 nickel-3% chromium), radiant furnace tubes (27 chromium-13% nickel), and furnace rolls (35 nickel-15% chromium).

In stainless compositions, tubing over 8 in. in diameter is competitive with forged and rolled tubing, although small diameter tubing is more expensive. The larger the diameter, the more economical centrifugally cast stainless steels become, and the greater their competitive advantages.

Duplex metals

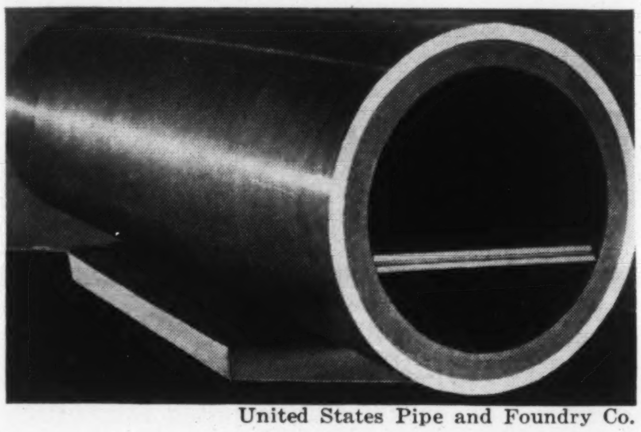
Centrifugal castings with one metal on the outside and another

. . . and these industrial applications



Sandusky Foundry & Machine Co.

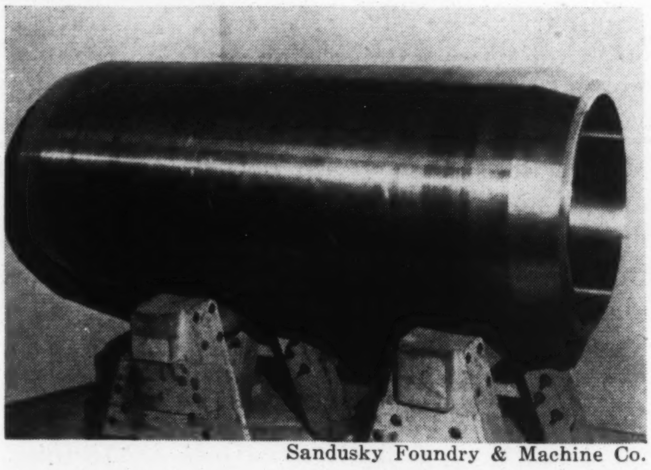
Paper machine suction press roll *produced from 12% chromium steel (Type CA15). This roll, 44 in. o.d. by 39-1/4 in. i.d. by 29 ft long, is drilled with hundreds of thousands of holes to permit use of suction in dewatering.*



United States Pipe and Foundry Co.

Textile rolls *used in impregnating various cloths with dyes and finishes come into contact with relatively corrosive media. Formerly made by cladding a cast iron roll with stainless plate, rolls are now produced as a composite shell. Outer layer is Type 316 stainless steel and the inner layer gray cast iron.*

Atomic power plant pressurizer shell, *requiring high resistance to corrosion by high-purity water steam at pressures to 2500 psi and temperatures to 650 F, was produced from 20 chromium—10.5% nickel steel (Type CF3). This shell is 27 in. o.d. by 22 in. i.d. by 66 1/4 in. long.*



Sandusky Foundry & Machine Co.

on the inside are also in commercial production. Combinations of hard and soft cast iron, carbon steel and stainless steel have been produced successfully.

Duplex metal parts have been centrifugally cast by two methods. In one, the internal member of the pair is cast within a shell of the other. This method has been used to produce aircraft brake drums by centrifugally casting an iron liner into a steel shell.

In the second method, both sections of the casting are produced centrifugally; the metal that is to form the outer portion of the combination is poured into the mold and solidified and the second metal is introduced before the first has cooled. The major limitation of this method is that the solidification temperature of the second metal poured must be the same or lower than that of the first. This method is said to form a strongly bonded duplex casting. Applications of this method include: grinding rolls for flour mills in which the outer layer is composed of chilled iron and the inner of gray iron; mixer bowls for various abrasive materials with the outer layer steel and the inner layer white iron; textile rolls with the outer layer ½ in. of stainless steel and the inner layer gray cast iron.

A severely abrasive application in the petroleum industry involved the handling of catalyst pellets. These pellets are gravity fed from a high tower through the reaction chamber and then lifted pneumatically through a vertical pipe for recycling. The lift pipes range from 15 to 25 in. i.d. and are as tall as 325 ft; they handle from 90 to 400 tons of pellets per hr. Lift pipes having the external layer steel and the internal Ni-Hard or abrasive resisting high chromium steel have been satisfactory in this service.

The possibilities of this duplex method for producing tubing for corrosion resistant applications and chemical pressure service are being investigated.

Acknowledgments

The assistance of the following organizations in the preparation of this article is greatly appreciated.

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Shenango Furnace Co., Centrifugally Cast Products Div.
United States Pipe and Foundry Co.

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	No-Draft	Conventional	Blocker Type[b]
Forging Cost, $	147.00	100.00	90.00
Dies[a] $	16.00	4.00	1.60
Machining $	50.00	125.00	185.00
Total Cost	213.00	229.00	276.60
Forging Weight, lb	8	28	90
Finished Weight, lb	6	6	6

[a] Dies amortized over production run of 2400 units.
[b] A simple die forging that can be made in a single set of forging die impressions.

This chart shows

Lower Costs with

Airframe and missile parts are produced as no-draft forgings close to finished dimensions, thus saving material and reducing machining time.

by Homer Harvey, *Vice President, Harvey Aluminum, Inc.*

■ Draft on a forging is objectionable because the excess metal reduces the efficiency of the section. As forgings are increased in size, elimination of this excess metal becomes increasingly important. The conventional method of eliminating the excess metal is by machining in a secondary operation. However, in recent years techniques and equipment have been developed that permit forgings to be produced with no draft, thus saving time and reducing costs by minimizing machining.

As the name implies, a no-draft forging is one having a zero degree angle measured from the side of the forging to the perpendicular to the forging plane. No-draft forgings can be produced in the common aluminum forging alloys such as 2014, 6061, 7075 and 7079. As shown in an accompanying table, properties in the forgings meet the requirements in Federal specification QQ-A-367d for forged parts.

There has been little demand for no-draft magnesium forgings. However, the forging behavior of magnesium alloys indicates that they are suitable for no-draft production. Titanium and steel parts are difficult to forge with zero degree draft, but are being produced experimentally.

Currently, aluminum no-draft forgings find widest use in airframes and missiles for structural fittings, corner brackets, can-type designs, and attachment fittings. Many forgings considered impossible to make a year ago are today in full production. Larger, more complex forged components are anticipated for future aircraft usage. Aluminum no-draft forgings are used also for trunk trailer attachment brackets, hydraulic fittings, and wherever "weight costs money."

Sizes and thickness

Many companies are producing aluminum forgings, but the forging of no-draft parts is restricted to a few suppliers. Aluminum no-drafts are made on hydraulic or mechanical presses and usually require pressures in the range of 15 tons to 35 tons per sq in. Most no-draft parts in use today range in size from 10 to 250 sq in. Size is directly dependent on press equipment and die-sinking capabilities. The die bed on an 8000 ton hydraulic press will accommodate most of the aluminum no-draft forgings now being designed.

The web thickness of a draftless forging also influences the press size.

However, webs less than 0.150 in. thick should be avoided. If deep narrow pockets are unavoidable, punch-out holes should be incorporated in the web to permit outward flow of excess metal dur-

***Structural fittings** and corner brackets are produced as no-draft forgings.*

No-Draft Forgings

ing forging. Large changes in section thickness should also be avoided, particularly if these changes are abrupt.

Tolerances

In general, tolerances on vertical walls or ribs can be held to 0.010 in. thickness; die closure tolerances can be held to 0.03 in.; length and width tolerances can be held within +0.004 and −0.002 in. Straightness tolerances depend on design of the part but are generally closer than those for conventional aluminum die forgings.

Many engineers erroneously believe that a no-draft forging must be a precision forging. Progressive designers and engineers are incorporating a zero-degree draft angle to avoid major machining, but at the same time are designing to commercial tolerances in order to gain better economies. By allowing broader tolerances, forging producers can decrease tooling and production costs, reduce lead time, and use less engineering time.

Tight tolerances is one of the big reasons for costly tool charges and high piece price. Some types of newer equipment make closer tolerances possible without excessive costs. One example is a hydraulic press that uses die designs incorporating the entering punch type design necessary for perfect register in producing complex unsymmetrical forgings.

Relative costs

To compare the benefits gained by selecting a no-draft design over a conventional press forging, an engineer should consider two factors—time and cost. Some types of no-drafts require special die equipment making the tooling time extensive and expensive, and of course stretching out the lead time.

Basic engineering and design in no-draft parts can also run up the cost and lead time required. In some cases, it is possible to produce a no-draft part for the same or less cost and time than a conventional draft forging. Conversely, in considering conventional draft forgings, the engineer must take into account not only the die charges and piece price and delivery, but the time and cost required to machine away the excess metal when weight is a factor. As shown in a table, overall cost of producing a part by no-draft forging can be considerably lower than the cost of producing the part by conventional methods.

In some applications, a no-draft angle is unwarranted; the part performs as well with a reduced draft angle such as 1 or 3 deg. Here the cost savings resulting from lower engineering and tooling time and faster production rates can out-weigh the advantages offered by a no-draft forging. Therefore, whenever possible, the designer and the forging engineer should discuss a critical forging during the design stage to establish whether the part should be made as a conventional closed die forging or as a no-draft forging.

COMPARISON OF SPECIFICATION REQUIREMENTS WITH PROPERTIES OF NO-DRAFT FORGINGS

Alloy ↓	Tensile Strength, 1000 psi		Yield Strength, 1000 psi		Elong, %	
	Fed Spec[a]	No-Draft[b]	Fed Spec[a]	No-Draft[b]	Fed Spec[a]	No-Draft[b]
Parallel to Forging Flow Lines						
2014-T6	65	72	55	63.5	7.0	10.0
6061-T6	38	46	35	41	7.0	17.0
7075-T6	75	84.5	65	75	7.0	11.0
7079-T6	74	78.5	64	71	7.0	12.0
Not Parallel to Forging Flow Lines						
2014-T6	62	73	52	60	3.0	7.0
7075-T6	71	83	62	74	3.0	10.0
7079-T6	72	77	61	70	4.0	11.0

[a] Federal specifications QQ-A-367d, minimum properties of die forgings.
[b] No-draft forgings, typical properties.

Koppers Co., Inc.

Injection molded parts *in Type III polyethylene include fire extinguisher horn, paint brush handle, paint roller handle and roller ends, drain baffle for dishwasher, insecticide spray cap, marine battery hold-down bolt, cord holder for electric shaver, and a bottle closure.*

An up-to-date report on

The New Polyethylenes

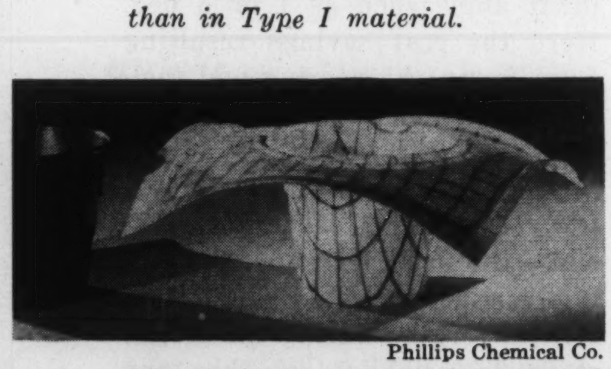
Part 2

Moldings and extrusions
Film
Fiber
Sheet
Coatings

by Malcolm W. Riley,
Associate Editor, Materials in Design Engineering

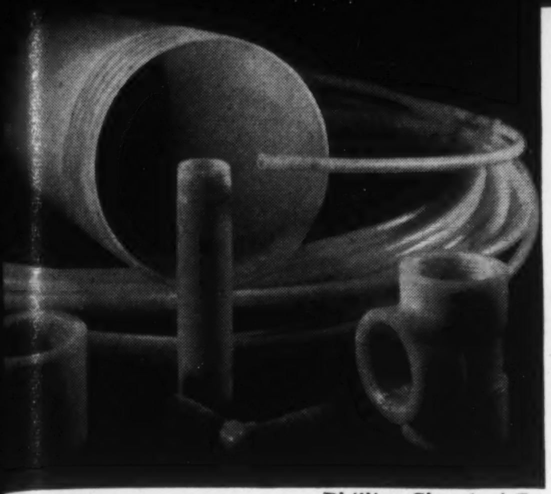
Koppers Co., Inc.

Blow molded containers, *more rigid in Type III polyethylene, can be produced in thinner wall section than in Type I material.*



Phillips Chemical Co.

Sheet *can be vacuum formed with relatively good flow characteristics even in deep draws, as shown by the cross-hatched test piece.*

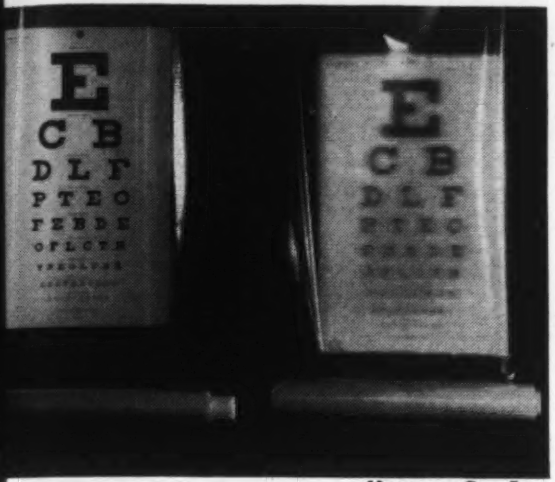


Phillips Chemical Co.

***Extruded pipe and tubing** in the new polyethylenes can be designed with higher hoop stresses.*

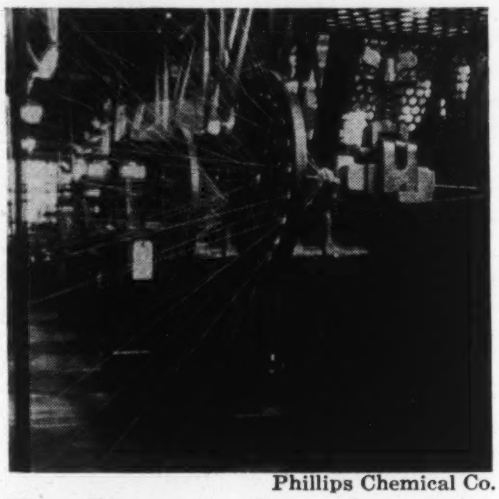
Phillips Chemical Co.

***Wire coatings** withstand elevated temperatures and have improved abrasion and cut-through resistance.*



Koppers Co., Inc.

***Film** of high density materials quenched for clarity can compete with cellophane.*



Phillips Chemical Co.

***Monofilament,** shown here being made into rope, is being used in marine rope, and a variety of textiles.*

■ The medium density (Type II) and higher density (Type III) polyethylenes have come of age as engineering materials. The development of substantial short and long term property information now permits quite accurate evaluation of these materials (see The New Polyethylenes—Part 1, M/DE, July '58, p 98). Also, the development of a substantial amount of design know-how, and recent improvements in the available forms permit the designer or engineer to use the materials most effectively in the design of his product.

Moldings and extrusions

The new polyethylenes can be formed on standard equipment by injection, compression or blow molding, and by extrusion. The early "problems," such as warpage, poor surface quality and lack of dimensional stability, were caused primarily by a lack of knowledge of the material. Although, in many cases, parts can be successfully formed in molds designed for other thermoplastics (such as modified styrenes, nylon or Type I polyethylene), optimum results are obtained in molds specifically designed for Type II and III materials.

In the following discussion, it should be borne in mind that the materials discussed cover a range in density of 0.926 to 0.965 gm per cu cm. Design or processing variables become more critical, of course, with higher densities. Thus, the discussion here generally considers the highest density conditions. Details concerning specific grades of materials should be discussed with the processor or materials supplier.

As is the case with any plastic, warpage and lack of dimensional stability are usually caused by internal stresses in the finished part, resulting from poor design or poor processing. Type II and III polyethylenes have relatively sharp melting and freezing points, which necessitate careful control over the temperature of the melt and the mold to prevent differential cooling, and resulting internal stresses.

Although mold shrinkage is similar to that of Type I polyethylene (0.020-0.050 in. per in.), shrinkage for any specific higher density part may be higher with higher processing temperatures. Also, due to the high melt viscosity of the materials, there will be a degree of orientation in the direction of flow resulting in higher shrinkage in that direction than in a direction perpendicular to flow.

In general, good plastics design principles are applicable to Type II and III materials. Of particular importance are the following general recommendations: 1) large variations in section thickness should be avoided; 2) large flat areas should, in many cases, have reinforcing ribs (these can also frequently serve as runners to aid rapid and uniform filling of the cavity); 3) maximum practical draft should be provided; and 4) sharp internal corners should be avoided. To assure best results, the molder, fabricator or materials supplier should be consulted in the initial design stage to determine feasibility of design from the standpoint of molding or extrusion efficiency.

Applications—Naturally enough, early applications of molded or extruded Type II and III polyethylene parts were primarily in non-critical applications, such as housewares and toys. The increased amount of engineering and design information now available has resulted in their use in applications such as valves and fittings for chemical processing equipment, corner gussets to support refrigerator cabinet inner linings, molded grids for water cooling towers, automotive heater ducts, dishwasher tubs, and housings for such equipment as chain saws, dehumidifiers and fans.

The ease with which the materials can be blow molded has stimulated substantial production of blown containers. Higher rigidity permits use of thinner walls in containers; containers

TABLE 1—COMPARATIVE PROPERTIES OF POLYETHYLENE FILMS

Property	ASTM Test Method	Type III Polyethylene (slot extruded)			Type II Polyethylene (slot extruded)	Type I Polyethylene (blown tubing)	Cellophane[a]
		0.5 - 0.7 mil	1.0 - 1.2 mil	1.5 - 1.7 mil	1.5 mil	1.5 mil	0.9 -1.0 mil
Density, gm/cu cm	Density gradient column	0.940-0.943	0.944-0.945	0.945-0.946	0.930	0.920	1.40-1.55
Tensile Strength, psi	D882-49T						
Machine Dir.		10,000-11,000	8000-8500	8000-8500	3400	1800-2200	15,000-16,000
Trans. Dir.		3000-4000	3500-4000	3500-4000	1700	1800-2200	6500-7500
Elongation, %	D882-49						
Machine Dir.		160-170	200-300	300-400	130	300-600	10-15
Trans. Dir.		5-10	75-150	350-450	330	300-600	10-35
Tear Strength, gm/mil	D1004						
Machine Dir.		400-500	300-400	300-400	190	150-300	100-150
Trans. Dir.		600-700	600-700	600-700	320	200-400	100-150
Coefficient of Friction	[b]	0.43	0.39	0.36	0.61	0.4-0.8[c]	0.18-0.22
Haze, %	D1003-52	6-9	8-15	19-21	8	6-30	3-4
MoistureVapor Transmission, gm/24 hr/100 sq in./mil	E-96-53T	0.62-0.66	0.40-0.44	0.34-0.38	0.92	1.3-1.4	0.8-1.88
Gas Permeability, $\frac{\text{cu cm}}{\text{sq cm-sec-cu Hg}} \times 10^9$	[d]						
O_2		0.20-0.22	0.13-0.17	0.12-0.15	0.30	0.45	Dry: very low. Moist; variable and higher.
CO_2		0.64-0.78	0.48-0.54	0.43-0.47	1.0	1.25	
N_2		0.062-0.068	0.041-0.044	0.039-0.042	0.087	0.12	

[a] Moistureproof grades (M, MS, MSA).
[b] Inclined plane technique (Proposed ASTM Method).
[c] Lower values may be obtained with slip additives.
[d] Modified version of the permeability apparatus proposed by Brubaker & Kammermoyer, Ind Eng. Chem. 45, 1148 (1953).
Source: *Doyle.*

can also be sterilized, and the high strength of the materials permits their use in low pressure aerosol bombs for packaging foods, pharmaceuticals and chemicals.

Extruded pipe is being used where the heat resistance, high allowable hoop stresses, resistance to creep and high regidity of the Type II and III materials are advantageous. Fig 1 compares, at various temperatures, allowable continuous hoop stress for a Type III pipe with that of a Type I pipe. Fig 2 compares creep of a Type II polyethylene pipe with that of two Type I pipes.

Uses for extruded pipe include chemical processing, air conditioning, industrial piping, farm water distribution and lawn sprinkling. In general, present materials are not recommended for use in hot water house plumbing.

Film

As density increases, polyethylene films gain higher tensile strengths and become stronger, stiffer, have lower permeability to vapors and fluids, lower frictional coefficients (decreasing blocking, increasing slip), higher resistance to heat and better surface gloss. With densities higher than about 0.930-0.935 gm per cu cm, clarity of conventionally produced film is generally poor. However, clear films of the higher density polyethylenes are now being produced by some companies with haze ratings of 6 to 9%, compared to cellophane's 3-4%. Also, all polyethylene films are tasteless, odorless, non-toxic, non-cor-

***Packaging film** of Type II material with a combination of clarity, flexibility and strength has recently been introduced as bread wrapping material by Western-Waxide Div., Crown Zellerbach Corp.*

Spencer Chemical Co.

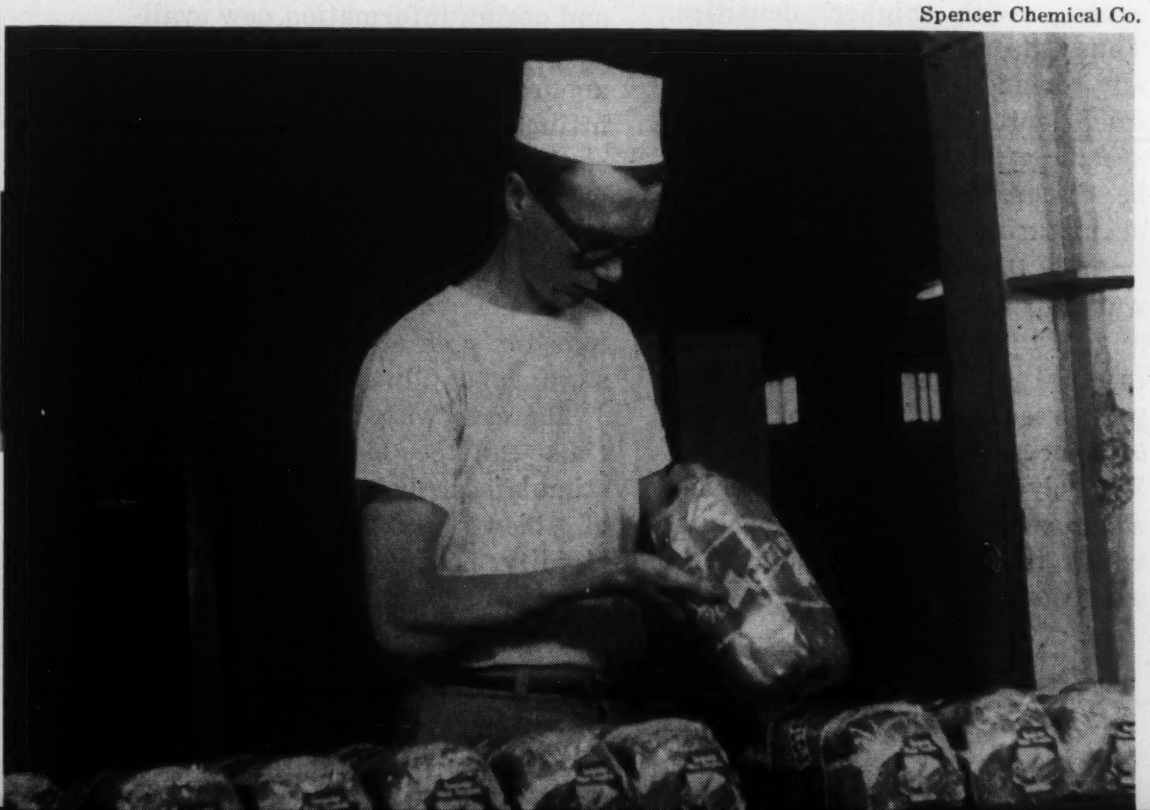


TABLE 2—PERMEABILITY OF TYPE III FILM (0.96 gm/cu cm) (gm/24 hr/100 sq in./mil)

Chemical ⬇	Vapor Permeability	Liquid Permeability
Amyl Alcohol	0.353	0.268
Ethylene Glycol	0.669	0.873
Acetic Acid	0.940	0.993
Aniline	1.09	1.27
Ethyl Alcohol	1.26	1.77
Oil of Peppermint	1.36	1.75
Butyric Acid	1.54	3.61
Benzaldehyde	2.45	3.92
Methyl Salicylate	3.39	3.92
Methyl Ethyl Ketone	4.12	8.05
Amyl Acetate	5.54	6.75
Diethyl Ketone	7.67	7.67
Ethyl Valerate	8.11	9.69
Butyraldehyde	9.86	12.58
Ethyl Acetate	13.7	13.7
N Butyl Ether	19.3	34.3
Butyl Iodide	52.04	112.72
Heptane	54.0	69.7
Butyl Chloride	69.63	86.05
Butyl Bromide	76.15	113.19

Source: Phillips Chemical Co.

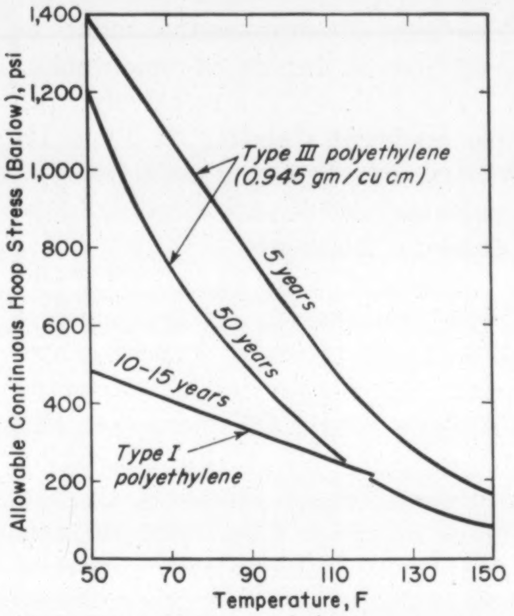


Fig 1—*Allowable hoop stress of a common size pipe made of Type III and of Type I polyethylene at various temperatures.* (Hercules)

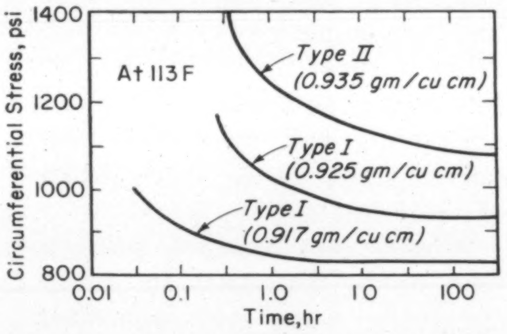


Fig 2—*Creep of Type II pipe at 113 F compared with that of two Type I pipes.* (Spencer)

rosive, flexible at low temperatures, heat-sealable, and unaffected by moisture.

Table 1 gives typical properties of Type II and III polyethylene films compared with properties of a Type I film and cellophane. Properties of films vary with suppliers as well as with density, and no attempt is made here to show comprehensive values obtainable. The data were taken from film made from an 0.96 gm per cu cm resin; however, quenching to obtain clarity inhibits crystalite growth, producing lower densities in the film. Blown film (unquenched) will have a density closer to that of the annealed parent resin.

As shown in Fig 3, permeability of polyethylene film decreases with increased density. Table 2 lists typical liquid and vapor permeability values for a maximum density Type III material.

Applications—Primary use for polyethylene films is for packaging where barrier characteristics are important. Type II and III films are applicable for such packaging as hygroscopic foods, moist foods, certain bakery goods and prepared meats; clothing; possibly some types of hard goods, such as delicate instruments and oily metal parts; and linings for drums, cartons, and pails for hot liquids, chemicals and oils. A most promising potential application is as an overwrap material competitive with cellophane.

Other applications include thermoformed trays and containers, narrow slit widths for rope and specialty textiles, light diffuser panels, pipe wrap and weather and corrosion resistant tarpaulins.

Fibers

Fibers of Type II and III polyethylene, in addition to the properties common to all polyethylenes, have a high degree of toughness, strength and abrasion resistance. Their most prominent property, high strength, is shown in Fig 4 and 5. The curves in Fig 6 show tensile and yield strength as directly proportional to the degree of stretch or orien-

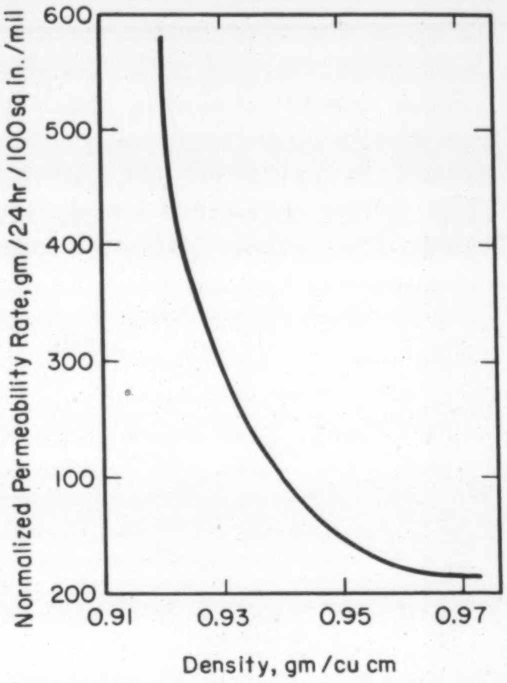


Fig 3—*Normalized permeability rate of benzine versus density of polyethylene film.* (Martinovich)

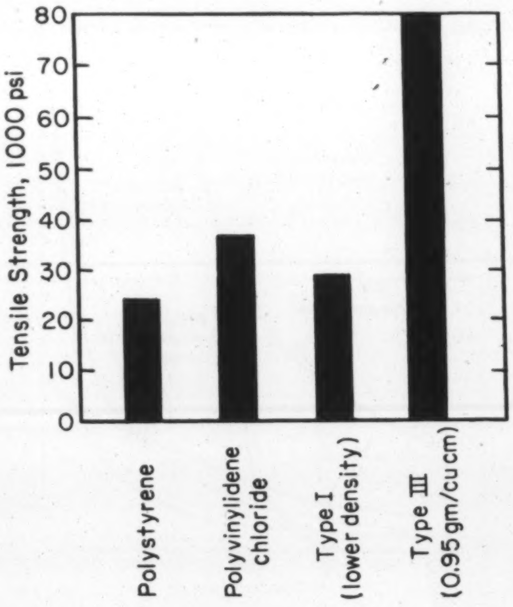


Fig 4—*Comparative tensile strengths of Type III polyethylene fiber and several others.* (Groel)

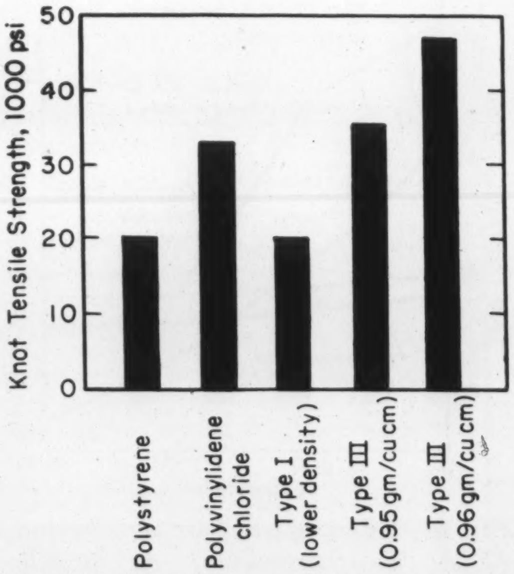


Fig 5—*Comparative knot tensile strengths of Type III fibers and several others.* (Groel)

tation of the fiber, while elongation varies inversely with stretch.

Knot tensile strength reaches a maximum value at about 800% stretch, dropping off thereafter. Thus, where maximum tensile as well as knot tensile strengths are desired, a compromise must be reached in degree of orientation.

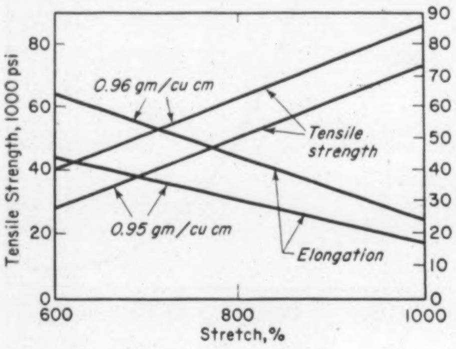


Fig 6—*Effect of stretch, or orientation, on tensile strength and elongation of two Type III polyethylene fibers.* (Groel)

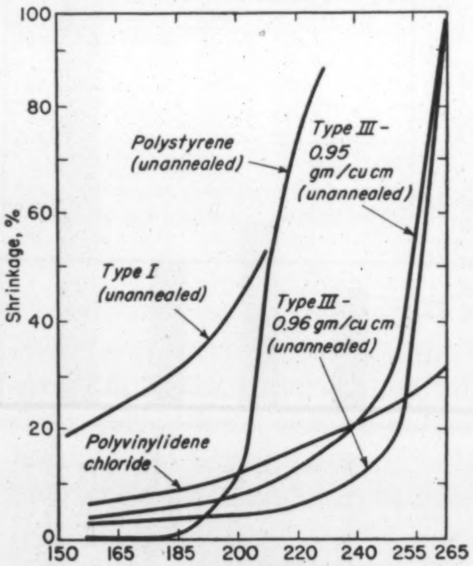


Fig 7—*Dimensional stability of various synthetic fibers.* (Groel)

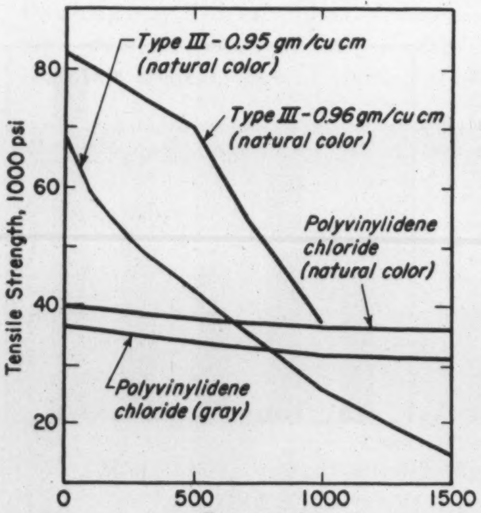


Fig 8—*Effect of outdoor weathering (XIA Weatherometer) on tensile strength of two Type III polyethylene and two polyvinylidene chloride fibers.* (Groel)

Fig 7 shows the relatively high dimensional stability of Type III fibers, as compared with that of polystyrene and polyvinylidene chloride filaments.

Although Type II and III fibers have weathering characteristics similar to those of Type I materials, the higher initial strengths of Type II and III fibers (see Fig 8) partially offset this limitation for some design purposes. Carbon black or other fillers and antioxidants will substantially improve weatherability.

Applications — Polyethylene fibers are used in making rope and a variety of textile products. Ropes made of the fibers have extremely low water absorption and are superior to those made from natural fibers in resistance to rotting and attack by marine organisms and chemicals. Also, polyethylene ropes float because of their low specific gravity.

Woven into fabrics, polyethylene fibers are used in outdoor furniture, auto seat upholstery, chemical protective clothing, chemical filtration, netting, rugs, tarpaulins and curtains.

Sheet

The use of Type II and III sheet for thermoforming has been relatively limited. The sharp melting point of the material caused some initial difficulties, but processing techniques have now become well developed. Vacuum formed parts with uniform section thickness can be produced easily and efficiently, even on deep draws. In forming parts with large flat sections, careful control of mold surface temperature is necessary to prevent warpage.

Applications—The rigidity, high surface gloss, excellent light diffusion characteristics, sterilizability and resistance to heat of Type II and III sheet materials make them suitable for a variety of thermoformed parts. These include light diffuser panels, industrial and sports helmets, luggage, refrigerator and other appliance parts, trays for domestic and institutional use, hospital wares, packaging and display signs.

Wire and extrusion coatings

In addition to the properties obtainable in Type I wire insulation, Type II and III materials offer improved abrasion resistance, cut-through, and resistance to elevated temperatures. The higher rigidity of the materials must be considered, since it means a more rigid wire assembly, and permissible bend radii must be larger than with Type I coated wire. Coatings for exterior wires are usually compounded with carbon black to improve weatherability.

Type II and III materials can be applied as an extrusion coating to materials such as paper, fabrics, other films and foil. Adhesion to paper and fabrics is generally excellent, and the resulting product is harder, stiffer and has lower permeability and a lower coefficient of friction than coatings of Type I polyethylene. When coating on cellophane, polyester film or foil, a primed substrate improves adhesion under some operating conditions.

The major applications for extrusion coated papers, films and foils are as packaging materials. They provide heat sealability and strength and act as an effective vapor and fluid barrier.

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Phillips Chemical Co.
Semet-Solvay Petrochemical Div., Allied Chemical Corp.
Spencer Chemical Co.
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Sutro, F. C., Jr., "Medium Density Polyethylenes," paper delivered before the Cleveland Section, Society of Plastics Engineers, Oct '57.

A Guide to Materials Standards and Specifications

Part 6—Finishes and Coatings

by S. P. Kaidanovsky,
Consulting Engineer

■ Standards and specifications on finishes and coatings are prepared or issued by most of the Governmental agencies and national organizations, such as the Federal Supply Service, Dept. of Defense, American Society for Testing Materials, the Society of Automotive Engineers and the American Standards Assn. Their standardization activities were covered in Part 1 of this series. In addition, a number of trade and technical societies concerned with finishes and coatings prepare standards or assist standards agencies which are summarized in the accompanying table.

American Electroplaters' Society

The American Electroplaters' Society (AES) is an educational organization for the advancement of electroplating, metal finishing and allied arts. Basic research on the fundamental problems of the industry is under direction of a research committee, and is conducted in various universities and institutions, and at the National Bureau of Standards.

The AES maintains intersociety representation with the American Society for Testing Materials, American Standards Assn., the Electrochemical Society, National Assn. of Corrosion Engineers, Society of Plastics Engineers, and trade associations of metal finishers.

Specifications for electrodeposited metal coatings are prepared jointly by the AES, the National Bureau of Standards and the American Society for Testing Materials, and are issued as ASTM-AES specifications.

National Association of Metal Finishers

The National Association of Metal Finishers (NAMF) is an organization in the field of electroplating, metal finishing, polishing, buffing and allied arts. At present the Standards Committee of the association is setting up a series of plating standards, the first of which specifies the thickness of plating for various applications. The standard for each application is designated by the letters NAMF, followed by a number 1, 2, 3, etc. in parenthesis. Thus, NAMF (1) designates the thickness of hard chromium plating for carburetor parts and die casting dies.

American Hot Dip Galvanizers Assn.

The American Hot Dip Galvanizers Assn., Inc. (AHDGA) is a trade association representing the hot dip galvanizing industry. One of the principal activities of the association is technical research and development of specifications for hot-dip galvanized coatings. The association works with the American Society for Testing Materials, the American Electroplaters' Society, the National Assn. of Corrosion Engineers and the American Zinc Institute.

Where to Obtain Standards for Finishes and Coatings

American Society for Testing Materials
1916 Race St., Philadelphia 3, Pa.
ASTM Standards, Part 2—Nonferrous Metals; Part 4—Paint, Varnish, Lacquer and Related Products.
Each standard available separately.[a]

Society of Automotive Engineers
485 Lexington Ave., New York 17, N. Y.
SAE Handbook. Each AMS available separately.[a]

Federal and Military
Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C.
Each specification available separately.[a]

American Standards Assn.
70 E. 45th St., New York 17, N. Y.
Each standard available separately.[a]

National Assn. of Metal Finishers
60 Bently Rd., Cedar Grove, N. J.
Each specification available separately.

American Hot Dip Galvanizers Assn.
1806 First National Bank Bldg., Pittsburgh 22, Pa.
ASTM Standards on Hot-Dip Galvanized Coatings; Tentative Standard Specifications for Hot-Dipped Zinc Coated Iron and Steel Products.

Federation of Paint and Varnish Production Clubs
121 S. Broad St., Philadelphia 7, Pa.
Paint, Varnish, Lacquer and Related Products.
Each Federation standard available separately.

National Paint, Varnish, and Lacquer Assn., Inc.
1500 Rhode Island Ave., N.W., Washington 5, D. C.
Guide to United States Government Paint Specifications, by W. M. Laval.

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[a] See first article (Mar '58) for information on index. Use of standards issued by trade associations should not be considered mandatory.

This is the last of six articles. All articles in this series will be made available as a reprint (75¢).

The association publishes *Tentative Standard Specifications for Hot-Dipped Zinc Coated Iron and Steel Products* and distributes a publication, *ASTM Standards on Hot-Dipped Galvanized Coatings*, compiled by the American Society for Testing Materials.

Federation of Paint and Varnish Production Clubs

The Federation of Paint and Varnish Production Clubs (FPVPC) is a technical society of the decorative and protective coatings industry and allied industries. The federation has many committees on such subjects as materials, manufacturing, corrosion and research. One of the most important is the Committee on Standards and Methods of Test.

There is close cooperation between the federation and the American Society for Testing Materials. A Joint Federation-ASTM Committee acts as a liaison body between the federation and the ASTM on all matters pertaining to standards and methods of test. Through this joint committee the federation cooperates with the ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products. The federation also cooperates with other technical organizations, the National Society of Corrosion Engineers, Inter-Society Color Council, Steel Structures Painting Council and others. The federation has recently incorporated a Paint Research Institute to conduct basic research in polymer chemistry and colloidal chemistry.

All standards approved by the federation and the Joint Federation-ASTM Committee, known as Federated Standards, are compiled in *Paint, Varnish, Lacquer and Related Products*. A number of standards contained in this compilation have also been approved by the American Standards Assn.

National Paint, Varnish, and Lacquer Assn.

The National Paint, Varnish, and Lacquer Assn. Inc. is a trade association of the paint, varnish, and lacquer industry. The association does not issue its own standards or specifications, but works closely with the American Society for Testing Materials, the American Oil Chemists Society, the Steel Structures Painting Council, and various groups of paint users, to ascertain that the specifications and methods of tests are in accord with current industry practice.

The association cooperates with agencies of the Federal Government, both military and civil, and has compiled a guide with quarterly supplements entitled *Guide to United States Government Paint Specifications*, con-

SUMMARY LIST OF STANDARDS AND

Organization	Type of Document	Document Identification[g]	Finishes, Uses
CONVERSION COATINGS			
ASTM[a]	Spec	B201[b]	Chromate finishes on electrodeposited zinc, hot-dip galvanized, and zinc die-cast surfaces
Military	Spec	MIL-A-8625	Anodic coatings for aluminum
Military	Spec	MIL-F-495	Black oxide finish for iron and steel
Military	Spec	MIL-C-13924	Black oxide finish for iron and steel
Military	Spec	MIL-C-17711	Chromate coatings for zinc alloy castings and hot-dip galvanized surfaces
Military	Spec	MIL-C-12987	Chrome coating
Military	Spec	MIL-C-12968	Phosphate coating for iron and steel
HOT DIP COATINGS			
ASTM	Spec	AXXX[c]	Hot-dip (galvanized) zinc coatings on products from rolled, pressed, and forged steel shapes, plates, bars, and strip; on assembled steel products; on iron and steel hardware
AHDGA	Spec	—	Hot-dip (galvanized) zinc coatings on iron and steel products
Military	Spec	MIL-Z-17871	Hot-dip (galvanized) zinc coatings
ORGANIC FINISHES			
ASTM	Spec	DXX[d]	Lacquer and lacquer materials
ASTM	Spec	DXX[d]	Shellac and varnish materials
Federal	Spec	TT-L-XX	Cellulose nitrate lacquer
Federal	Spec	TT-V-XXX	Spar varnish—alkyd-resin and phenolic-resin
Military	Spec	MIL-C-XXX	Acrylic coating
Military	Spec	MIL-C-XXX	Phenolic-resin base coatings
Military	Spec	MIL-P-15143	Phenolformaldehyde coating
Military	Spec	MIL-R-XXX	Resin coatings—para-phenyl, phenolformaldehyde; phenolic, oil soluble
Military	Spec	JAN-E-480	Phenol or urea-formaldehyde baking enamel
Military	Spec	MIL-E-5557	Glyceryl-phthalate black enamel (heat resisting)
Military	Spec	MIL-E-13515	Vinyl-alkyd enamel
Military	Spec	MIL-L-7178	Cellulose nitrate lacquer. Aeronautical uses
Military	Spec	MIL-L-14486	Vinyl-resin lacquer
Military	Spec	MIL-V-6894	Oil-type varnish, glyceryl phthalate base
Military	Spec	MIL-V-173	Varnish (moisture and fungus resistant) for communications, electronic, and electrical equipment
Military	Spec	MIL-V-XXX	Varnish—phenolformaldehyde (clear and aluminum pigmented); oil-type, glyceryl phthalate base; phenolic, baking
Military	Spec	MIL-P-15076	Polymer-powder (organic dihalide and inorganic polysulfide) coating
Military	Spec	MIL-R-3043	Resin-coating for internal engine parts
SAE	Spec	AMS 312X	Glyceryl phthalate and phenolic enamel. Aeronautical uses
SAE	Spec	AMS 3125	Glyceryl phthalate enamel. Aeronautical uses
SAE	Spec	AMS 31XX	Ocher phenolic and zinc chromate primer. Aeronautical uses

SPECIFICATIONS FOR FINISHES AND COATINGS

Organization	Type of Document	Document Identification[g]	Finishes, Uses
PLATED COATINGS			
ASTM-AES	Spec	AXXX[e]	Electrodeposited zinc, cadmium, nickel and chromium, and lead on steel
ASTM-AES	Spec	BXXX[f]	Electrodeposited nickel and chromium on copper and copper-base alloys, and on zinc and zinc-base alloys
Federal	Spec	QQ-P-416	Electrodeposited cadmium
Federal	Spec	QQ-C-320	Electrodeposited chromium
Federal	Spec	QQ-N-290	Electrodeposited nickel
Federal	Spec	QQ-S-365	Electrodeposited silver
Federal	Spec	QQ-Z-325	Electrodeposited zinc
Military	Spec	MIL-P-20218	Electrodeposited porous chromium
Military	Spec	MIL-L-13808	Electrodeposited lead
Military	Spec	MIL-R-2611	Rhodium electroplating solution
SAE	Spec	AMS 24XX	Electrodeposited copper, cadmium, nickel, zinc, chromium (hard and porous). Tin and tin immersion. Silver copper strike (low brake). Lead and indium lead. Diffused nickel-cadmium. Aluminum for solderability. Aeronautical uses
NAMF	Std	NAMF (x)	Electroplated chromium (hard) thicknesses
PORCELAIN ENAMELS			
Military	Spec	MIL-E-6802	Porcelain enamel coating
Military	Spec	MIL-P-16961	Porcelain enamel coating on steel mufflers of internal combustion engines
GENERAL			
Military	Spec	MIL-E-16400	Finishing design requirements for naval electronic equipment
Military	Spec	MIL-E-5400	Finishing design requirements for airborn electronic equipment

[a] Endorsed by AES. [b] American Standard ASA G53.9. [c] American Standard ASA G8.XX.

[d] American Standards: ASA Group K, Chemical Industry.

[e] American Standards: ASA G53.1, G53.2, G53.3, and G53.8.

[f] American Standards: ASA G53.4 and G53.5.

[g] XXX in the document identification indicates that more than one standard has been developed on the material. Revisions, amendments and year are not indicated. When ordering, the latest issue is supplied.

taining brief abstracts concerning paint and related materials.

Porcelain Enamel Institute

The Porcelain Enamel Institute, Inc. (PEI) is a trade association for the porcelain enamel industry. Its membership includes companies manufacturing all types of porcelain enamel products, producers of base metals and frits, and suppliers of materials and equipment to the industry.

The PEI has several committees, one of which is the Quality Development Committee. This committee is responsible for all phases of quality improvement of the base metal, frit and the two combined. It develops specifications for end products and standards for testing and evaluating the properties of porcelain enamels, and the apparatus for making such tests. For this purpose, the PEI maintains a research associateship at the National Bureau of Standards.

The PEI works with government agencies in developing and maintaining up-to-date Commercial Standards and Federal Specifications (described in the Mar '58 issue of this series), and acts as a source of information on porcelain enamel to the Federal Government. The PEI cooperates with other trade associations and organizations concerned with porcelain enamel and its applications.

Electrochemical Society

The purpose of the Electrochemical Society, Inc. is the advancement of science and technology of electrochemistry, electronics, electrometallurgy, electrothermics and allied subjects. The society does not issue its own standards; however, through its several committees it cooperates with the American Electroplaters' Society, the American Society for Testing Materials, the American Standards Assn., and the Inter-Society Committee of the National Assn. of Corrosion Engineers. The Society's monograph, *Modern Electroplating*, contains valuable information for the development of specifications for electrodeposited metal coatings.

ASTM designations

The designations of electrodeposited metallic coatings are given in ASTM Specifications A164, A165, A166, B141, B142 and B200. The designation of type of coating consists of two letters: the first letter designates the grade of plating, and is arbitrary; the second letter designates the basis metal, such as *S*—steel, *C*—copper and copper-base alloys, *Z*—zinc and zinc-base alloys. The accompanying table lists these designations, which have been adopted by the government and are used in the various Federal Specifications concerned with electrodeposited plating.

ASTM DESIGNATIONS FOR ELECTRODEPOSITED METALLIC COATINGS

Coatings ➜	Zinc	Cadmium	Nickel & Chromium	Nickel & Chromium	Nickel & Chromium	Lead
Grade of Plating	G,L,R	N,O,T	D,F,K,Q	F,K,Q	F,K,Q	E,EE,M,MM,P,PP
Basis Metal	S	S	S	C	Z	S
Type of Coatings	GS,LS,RS	NS,OS,TS	DS,FS,KS,QS	FC,KC,QC	FZ,KZ,QZ	ES,EES,MS,MMS, PS,PPS

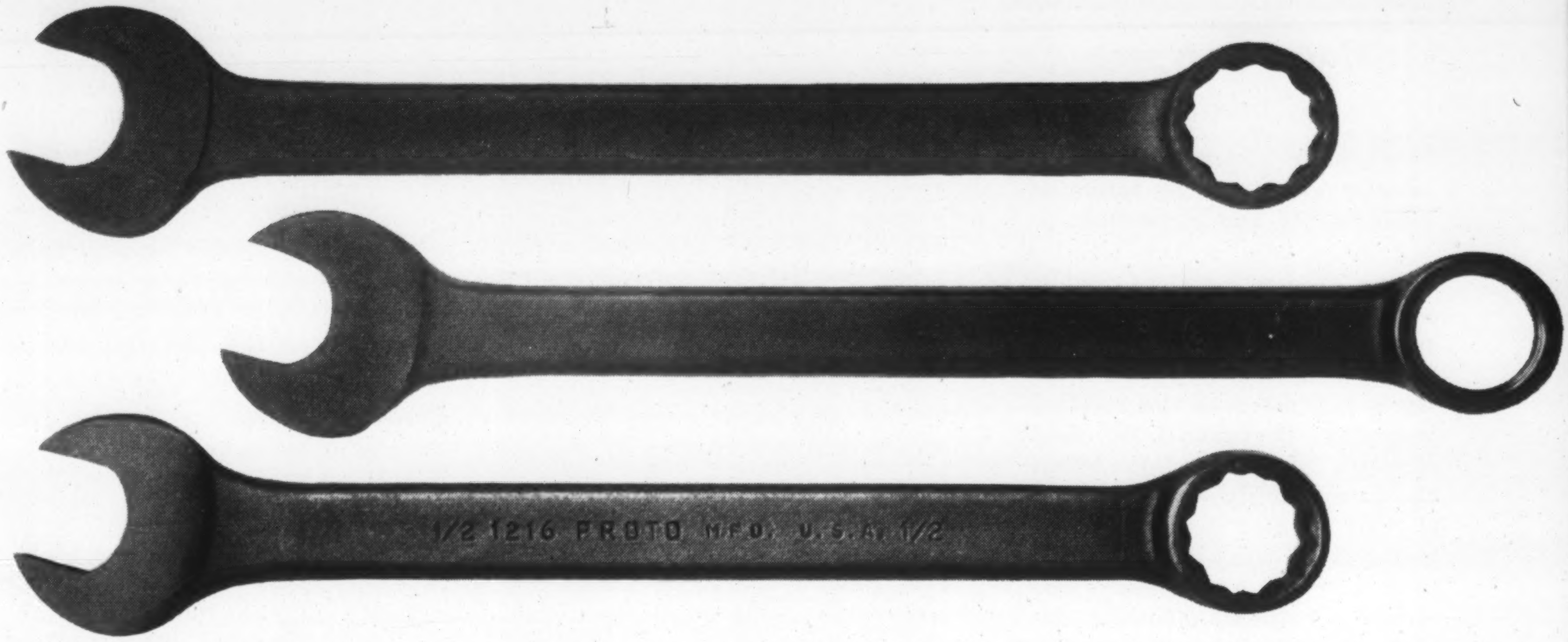
Safety tools *designed for use in vicinity of magnetic equipment are made from 310 stainless with cobalt-base alloy cutting edge inserts.*

Safety tools are one important use of . . .

High Strength Nonmagnetic Alloys

	Alloy ↓	Condition	Permeability	Max Tensile Strength, psi
Copper-Base Alloys	2% Beryllium Copper[a]	Heat treated (AT)	1.001	175,000
	2% Beryllium Copper	Cold worked and heat treated (HT)	1.001	200,000
	2% Beryllium Copper (over 0.15% Fe)	Heat treated (AT)	>1.010	—
	2.75% Beryllium Copper[b]	Heat treated (AT)	1.001	200,000
	Copper-20 Nickel-20% Manganese[c]	Heat treated	1.002	200,000
		Cold worked and heat treated	1.002	215,000
Cobalt-Base Alloys	Elgiloy[d]	Annealed	1.003 to >1.010	120,000
	Elgiloy	Cold worked 40% and aged	1.003 to >1.010	265,000
	Haynes 25[e]	Annealed	1.001	150,000
	Haynes 25	Cold worked 50% and aged	1.001	320,000
Titanium	(2 iron-2% aluminum)	Heat treated	1.010	200,000
Stainless Steels	304	Annealed	1.003	75,000
	304	Cold worked 10%	1.100	—
	310	Annealed	1.003	75,000
	310	Cold worked 50%	1.003	175,000
	Age Hardening Austenitic[f]	Heat treated	<1.010	195,000
	Age Hardening Austenitic	Cold worked 40%	1.2	—

[a] Berylco 25.
[b] Berylco 275.
[c] No. 720 (commercial designation).
[d] Cobalt-20 chromium-16 iron-15 nickel-7% molybdenum.
[e] Cobalt-20 chromium-15 tungsten-10% nickel.
[f] U.S. Steel: Iron-15 manganese-15 chromium-2 vanadium-0.6% carbon.



Experimental wrenches *for nonmagnetic applications made of standard steel titanium alloy, and beryllium copper.*

Metal parts used near highly sensitive magnetic devices must often have high strength as well as nonmagnetic properties. Here is an authoritative discussion on the steels and nonferrous alloys most suitable for such service.

by Harold Bernstein, *Metallurgist, U. S. Naval Gun Factory*

■ In many applications it is important that critical magnetic devices should not be magnetically affected by the materials used in nearby structures, equipment, and tools. A number of nonmagnetic nonferrous metals and stainless steels are available; however, the strength and other mechanical properties of these materials are often inadequate. In many applications, there is a need for nonmagnetic alloys with tensile strengths about 200,000 psi with approximately 5% elongation. The alloys which come closest to achieving these values are the copper and cobalt base alloys, titanium alloys, and austenitic stainless steels.

Copper-base alloys

Beryllium copper—A 2 beryllium–98% copper alloy (Berylco 25) can be used in applications where a nonmagnetic material with moderate strength is required. As shown in the accompanying table this alloy can attain a strength of 175,000 psi after standard heat treatment, but the elongation averages less than 2%. Variations in heat treatment designed to improve ductility have not been successful.

The 2 beryllium–98% copper alloy normally contains a small amount of iron impurities which largely determine the alloy's magnetic properties. The effects of iron on magnetic properties can be controlled by varying the solution-anneal temperature. For example, the permeability of beryllium copper containing 0.5% iron by weight is over 1.01 after a normal solution-anneal at 1450 F. However, permeability is reduced to 1.001 after a solution-anneal at 1550 F. After heat treatment the alloy's magnetic properties are relatively unaffected by short time exposure to temperatures up to 900 F.

Somewhat higher strengths can be obtained with a beryllium copper alloy containing 2.75% beryllium (Berylco 275). Standard heat treatment has produced tensile strengths of over 200,000 psi, but here again the usefulness of the material is limited in high strength applications by its low ductility.

Detrimental eddy current effects have sometimes been encountered when using fairly large flat shapes of beryllium copper. In such cases, materials with higher resistivity values, such as the copper-nickel-manganese and the titanium - aluminum - vanadium alloys, have proved to be acceptable substitutes for beryllium copper.

Copper–20 nickel–20% manganese—This alloy (known commercially as 720) combines low permeability (about 1.002) with high strength and adequate ductility. Some forging difficulties have been encountered with large ingots, but the alloy hot and cold works easily in small sections. It offers no machining problems and is readily welded and soldered.

Unlike beryllium copper, the

alloy has a high magnetic tolerance for iron, and the magnetic properties are unaffected by heat treatment. Iron contents of up to 1% can be tolerated with no change in magnetic properties. As shown in the table, maximum tensile strength of the alloy varies from 200-215,000 psi, depending on how it is processed.

Cobalt-base alloys

Elgiloy—The magnetic properties of this alloy (cobalt-20 chromium-16 iron-15 nickel-7% molybdenum) are generally satisfactory. However, due to unknown reasons, its magnetic properties are variable and occasionally unacceptable. As shown in the table, permeability can vary from 1.003 to as high as 1.01.

The alloy is not heat treatable, but by suitable processing it can be produced in tensile strengths ranging from 120,000 to 265,000 psi. It may readily be cold worked, but it is not amenable to press or hammer forging. Metal cutting operations are difficult, but the material can be machined satisfactorily if the proper tools and practices are used.

Haynes 25—This alloy (cobalt–20 chromium–15 tungsten–10% nickel) can be used in either the annealed or cold worked and age hardened condition. It has a magnetic permeability of 1.001 in all tempers and has consistently met the military specification (MIL-M-19595) for magnetic effect limits.

The material has a tensile strength of 150,000 psi and an elongation of 60% after annealing. Tensile strengths up to 320,000 psi and an elongation of 2%, are obtained after cold rolling (50% reduction) and aging. The material is particularly useful in applications where localized areas of high hardness are required.

Titanium alloys

Titanium alloys have excellent nonmagnetic properties because of their paramagnetic characteristics. An alloy such as 2 aluminum–2% iron has a permeability of less than 1.001 in all tempers with negligible remanence. The alloy can develop tensile strengths of up to 200,000 psi by suitable heat treatment.

Despite these advantages, the use of titanium in nonmagnetic applications has been held back by its comparatively high cost and by fabrication problems. These objections may be overcome in the future, but at the present time the material is not too popular for nonmagnetic uses.

Stainless steels

Type 304—In an annealed temper, this alloy has low permeability and remanence. However, its strength is comparatively low. Since the alloy does not respond to heat treatment its strength can only be raised by cold working. Unfortunately, cold working produces a phase change in the material and increases permeability. In the annealed state the permeability of the alloy is relatively low, about 1.003; whereas, permeability rises to 1.10 after 10% cold working.

Type 310—This stainless steel is much more magnetically stable than type 304. Permeability is 1.003 even after processing. Like the 304 alloy, 310 stainless can only be strengthened by cold working. Tensile strength can be raised from 75,000 psi in the annealed state to 175,000 psi after 50% cold working.

Age hardening stainless steel—This austenitic steel is now available in one grade (see table for composition) for nonmagnetic applications. Recommended heat treatment consists of a solution treatment at 2100 F for 15 min, followed by a water quench and aging at 1300 F for 8 hr. After treatment, the alloy has a tensile strength of 195,000 psi and a permeability of less than 1.01. In this condition it meets the requirements of MIL-M-19595.

Cold work after heat treatment produces a phase change which affects magnetic characteristics detrimentally. After 40% cold working permeability increases to 1.2. Thus, aside from the heat treatment described above, no further processing is recommended.

Magnetic Effects Explained

Magnetic characteristics are usually expressed in terms of permeability and remanence.

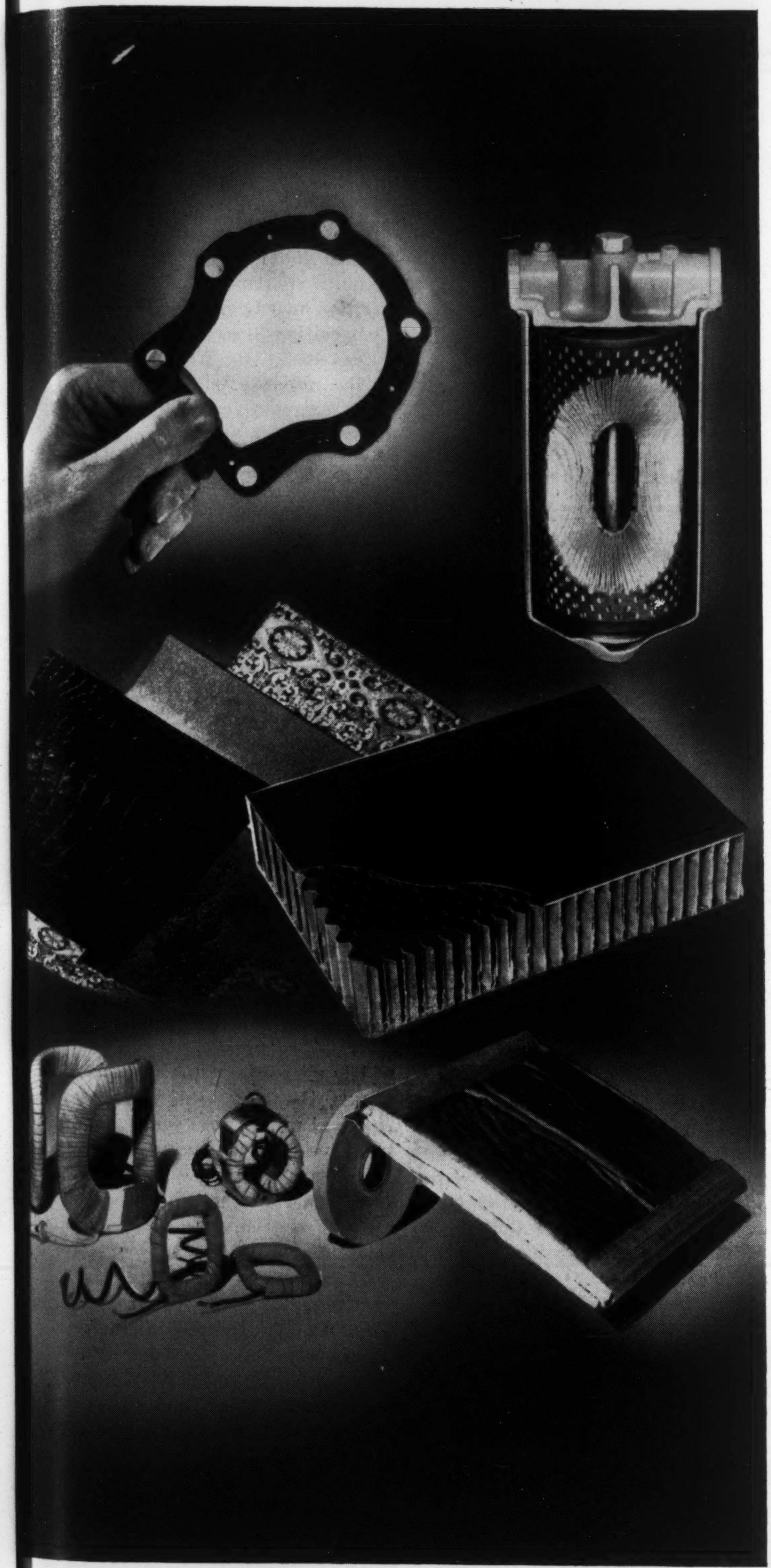
Permeability is the relative ability of a material to conduct magnetic lines of force as compared to air, which has unit value. Numerically, permeability is expressed as the ratio of induction B (gauss) to field strength H (oersteds). When the permeability value is only slightly greater than unity, the material is weak or paramagnetic (such as manganese). The strongly magnetic elements like iron and nickel have much greater permeability values.

Remanence is the residual magnetic effect in a material after exposure to a magnetic field (perming).

Eddy current effects are caused by the induction of an electromagnetic force in a conductor moving through the earth's magnetic field. The induced emf causes an eddy current to flow which generates a magnetic field to which the magnetometer is sensitive. The eddy current effect depends on two factors: resistivity and geometry. Low resistivity and a continuous current path favor the development of relatively large eddy currents.

Testing magnetic effects—The acceptance test for certain military equipment is based on MIL-M-19595 (Magnetic Effect Limits for Nonmagnetic Equipment and Metals), which specifies that metals or equipment be examined with a total field magnetometer which measures small changes in the earth's magnetic field caused by the object under test. The maximum change permitted is 0.10 milligauss.

This requirement cannot be readily expressed in terms of conventional magnetic parameters. However, it has been empirically determined that a material must have a permeability less than 1.01 and negligible remanence in order to meet the requirement.



Materials
in Design Engineering

Manual No. 151
August 1958

Paper
as an
Engineering Material

by Malcolm W. Riley,
Associate Editor,
Materials in Design Engineering

Paper is an extremely versatile and economical family of engineering materials. The nature of papers is such that very few standards or general property specifications can be established; thus, selection and specification is usually a case of individual trial and error.

This manual should help you determine where to use paper materials and how to work more intelligently with paper suppliers. It covers:

- *Types of papers*
- *Special treatments*
- *Applications*
- *Properties and tests*

Scope of the Manual

What it's about
Who it's for

The kinds of paper discussed here are those which are used as engineering materials and thus become a part of a final product. Papers used for such applications as writing, packaging or blueprint, are not covered, except to the extent that they are also used as engineering materials.

This manual is intended primarily for those designers and engineers who are either 1) unfamiliar with paper engineering materials, or 2) familiar with only a few types of papers in specific applications. Its purpose is to provide a working knowledge of engineering papers and to indicate their potential. It will familiarize you with 1) the basic types of papers available, 2) where they are used, and 3) their properties, which for the most part are not common to other engineering materials such as metals, plastics or ceramics.

■ Paper is an extremely useful and economical engineering material. It can provide a variety of combinations of properties, in some cases unique, and in some cases equivalent to those provided by more expensive materials.

Paper, according to the *Dictionary of Paper,* is a term used to describe "all kinds of matted or felted sheets of fiber (usually vegetable, but sometimes mineral, animal or synthetic) formed on a fine wire screen from a water suspension." This definition covers a broad and extremely versatile family of materials, made from a variety of fibers and in a variety of thicknesses. Due to space limitations, only fibrous papers are covered here. Paper-like materials such as those formed from platelets or flakes of mica and, more recently, glass are not included.

Though there is no distinct line between papers and paperboard, paper is usually considered as being less than 0.006 in. thick. Most materials ranging from 0.006 to 0.012 in. are papers, though some boards fall in this range; and most all fibrous materials over 0.012 in. in thickness are classified as board. (It should be pointed out that paperboard discussed here is produced as described above, and in many cases is quite similar to so-called composition board described in "Wood Composition Boards," MATERIALS & METHODS, Aug '57, p 107).

The major attribute of paper is its extreme versatility. A wide range of end properties can be obtained by control of the variables in 1) the original selection of the type and size of fiber, 2) the various pulp processing methods (see box p 112), 3) the actual web forming operation, and 4) the treatments which can be applied after the paper has been produced. Papers have been specifically developed for a number of engineered applications, among them gasketing; electrical, thermal, acoustical, and vibration insulation; liquid and air filtration; composite structural assemblies; simulated leathers and backing materials; cord or twine; and as yarns for textiles.

Basic kinds of papers

Cellulose fiber papers

By far the largest number of papers are produced from wood. The box on p 112 classifies the types of wood pulp used in papermaking. A great many of the engineering papers are produced from kraft or sulfate pulps. The term kraft today is used broadly for all types of sulfate papers, although it is primarily descriptive of the basic grades of unbleached sulfate papers where strength is the chief factor, and cleanliness and color are of secondary interest. By various treatments, kraft can be altered to produce various grades of condenser, insulating and sheathing papers.

Other types of vegetable fibers used to produce papers include:

Rope for strong, pliable papers such as required in cable insulation, gasketing, bags, abrasive papers and pattern papers.

Jute for papers possessing excellent strength and durability.

Straw for corrugating papers and wallboard.

Bagasse for wallboard and insulation, usually where strength is not a primary requirement.

Esparto for high grade book or printing papers. There are a number of other pulps also used for these types of papers.

Inorganic fiber papers

There are three major types of papers made from inorganic fibers:

Asbestos papers — The most widely used of the inorganic fiber papers, they are noninflammable, resistant to elevated temperatures and have good thermal insulating characteristics. They are available with or without binders and can also be used for electrical insulation.

Glass papers—Porous and nonhydrating, they can be used for filtration and thermal and electrical insulation. They are available with or without binders. High purity silica glass papers are available for high temperature applications.

Aluminum silicate ceramic papers—They provide good resistance to elevated temperatures, low thermal conductivity, good dielectric properties, and can be produced with good filtering characteristics.

Synthetic organic papers

A great deal of research has been carried out on the use of such synthetic fibers as nylon, polyester and acrylic fibers in papers. As yet, these papers are, for the most part developmental, but they appear to hold promise where the chemical or mechanical characteristics of the base fibers would be useful. They are generally combined with other fibers in a paper, primarily to add strength.

Paper treatments

Paper can be impregnated or saturated, coated, laminated, or mechanically treated. The discussion here covers the major treatments used, to indicate the extent of treatments available.

Impregnation or saturation

Impregnation or saturation can be carried out either at the beater stage in the processing of the pulp, or after the paper web has been produced. Beater saturation has the benefit of permitting saturation of nonporous or absorbent papers, whereas, papers to be saturated or impregnated after manufacture, must be absorbent to permit complete saturation with the impregnant. Beater saturation in some cases can also provide more uniform, intimate mixing of the additive and the pulp.

Papers can be saturated or impregnated with almost any known resin or binder. Probably the most commonly used are asphalt for moisture resistance; waxes for moisture vapor and water resistance; phenolic resins for strength and rigidity; melamine and certain ureas for wet strength (not to be confused with moisture resistance); rubber latexes (both natural and synthetic) for resilience, flexibility, strength and moisture resistance; epoxy or silicone resins for dielectric characteristics or dielectric characteristics at elevated temperatures; and ammonium salts, or other materials for flameproofing.

A number of proprietary beater saturated papers are currently available. They are used primarily for gasketing, filtration, simulated leathers and backing materials. Most of these consist of cellulose or asbestos fibers blended with natural or synthetic rubbers. In some cases cork is added to the blend for increased compressibility. Another type of proprietary beater saturated paper consists of leather fibers blended with rubber latexes.

Coatings

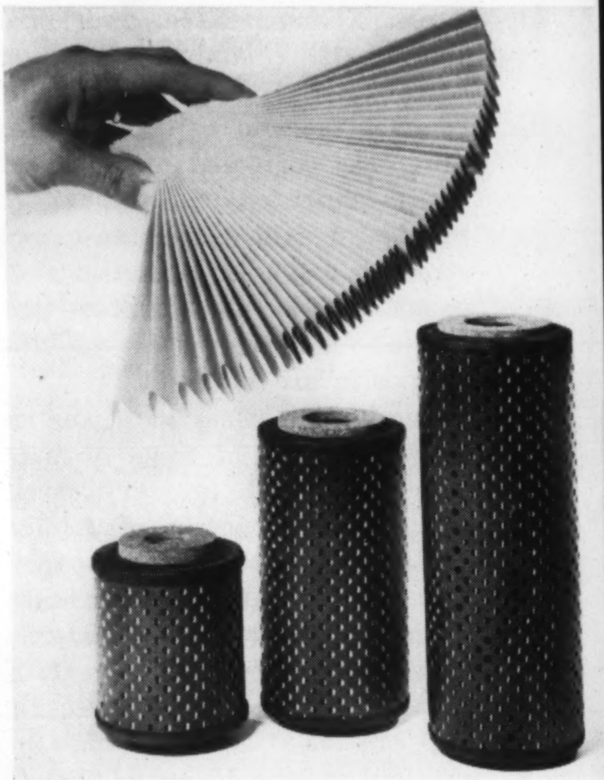
Papers may be coated either by the paper manufacturer or by converters. Coating materials, which also impregnate the paper to a greater or lesser degree, include practically every known resin or binder and pigment used in the paint industry. Coatings can be applied in solvent or water solutions, water emulsions, hot melts, and extrusion coatings, or in the form of plastisols or organisols.

The most important properties provided by coatings are 1) gas and water vapor resistance, 2) water, liquid and grease resistance, 3) flexibility, 4) heat-sealability, 5) chemical resistance, 6) scuff resistance, 7) dielectric properties, 8) structural strength, 9) mold resistance, 10) avoidance of fiber contamination and 11) protection of printing.

Coating materials range from the older materials, such as asphalt, wax, starch, casein, shellac and natural gums, to the newer polymers such as polyethylene, vinyl copolymers, acrylics, polystyrene, alkyds, polyamides, cellulosics and natural or synthetic rubbers.

The coating material that has probably received the most interest recently is polyethylene. Polyethylenes are primarily used to provide low moisture vapor transmission and grease resistance for packaging applications, as well as heat sealing qualities.

Flock coatings can be applied to papers for decoration, sound absorption, vibration cushioning and surface protection. Flock con-



Purolator Products, Inc.

Filtration *of air and oil is a major use for paper. Most such papers are resin-impregnated cellulose, though in many cases special papers are developed for specific filter jobs.*

Dennison Mfg. Co.

Coil insulation *here consists of crepe paper shown being wrapped on buffer coil. Conformability and stretch of creped paper simplifies hand-taping. Crepe papers can also meet high dielectric and cleanliness requirements for oil-filled or Askarel-filled transformers.*

sists of extremely short (usually 0.015 to 0.060 in.) fibers usually of rayon, cotton, hair or wool, and is applied to adhesive coated paper by spraying, vibrating or electrostatic techniques.

Laminations

Paper can be laminated to other papers or to other films to provide a great variety of composite structures. (Paper-based industrial thermosetting laminates are not covered here.) Probably the most common types of paper laminates are those composed of layers of paper laminated with asphalt to provide moisture resistance and strength. Simple laminations of paper can be so oriented that over-all characteristics of the composite are isotropic.

Laminating paper with plastics or other types of films or with metal foils will, in many cases, combine the properties of the film or foil with those of the paper.

Scrim is a mat of fibers, usually laminated as a "core" material between two faces of paper. It is usually used to provide strength, but can also provide bulk for cushioning, or a degree of "hand" to the composite material.

Mechanical treatments

Crimping, which adds stretch to papers, can be performed in two distinct ways, to provide two types of paper:

Creping imparts stretch, strength, bulk, and conformability and texture similar to that of cloth. The creping process usually consists of "crowding" the paper into small pleats or folds with a "doctor." Typical range of elongation or stretch obtainable by creping is 20 to 300%. Cross-creping can provide controllable degrees of stretch in directions perpendicular to each other, and thus further improve drapability (see "Cross-Creped Kraft," M/DE, Nov '57, p 138).

A relatively new paper material, trademarked Clupak, with a high degree of stretch, conformability and flexibility is produced by a patented process which differs from creping in that the individual fibers in the paper web are crimped, rather than the web itself. Amount of stretch is variable, but about 10% stretch in the machine direction seems to be optimum for most industrial applications. The major advantages of this type of paper are reported to be a high degree of toughness, a smooth surface and a high resistance to tearing or punching.

Twisting converts paper to twine or yarns. Such yarns have substantially higher strength than the paper from which they are made.

Twisting papers are usually sulfate papers, either bleached or unbleached, with basis weight usually varying from 12 to 60 lb. High tensile strength is required in the machine direction, and the heavier weight papers should usually be soft and pliable. Treatments to impart such characteristics as wear and moisture resistance can be applied during or after the spinning operation.

Embossing, in a variety of patterns, is primarily used for decorative purposes. It does not usually improve strength significantly. Embossing or "dimpling" in certain patterns, then laminating the sheets can provide composites with added strength, as well as bulk and heat insulation.

Miscellaneous—There are other mechanical operations primarily used for fabrication. These include 1) shredding for bulk or padding, 2) pleating, used as a forming aid and for strength in paper cups and plates, 3) die cutting and punching, and 4) molding, which consists of compressing the wet pulp web in a mold to form a finished shape, such as an egg crate.

Engineering uses of papers

Although the major engineering applications described here do not include all such uses for papers, they are the most important. Since many types of papers can be used for each type of application, depending on the specific design requirements, there is no attempt here to list all types in each category of application. In many cases, specific papers have been developed to meet individual requirements.

Filtration

In filtering units, paper can be used either as a labyrinth barrier material to guide the fluid or gas to be filtered or, more commonly, it can be used as the filtering medium itself. In the former case, surface finish and impermeability are critical; in the latter, controlled permeability or flow rate, and solids retention are critical.

Papers are used for both oil and air filtration in automobiles. Probably the most common papers for such applications are phenolic-impregnated kraft, though many specialized filter papers have been developed to meet specific automotive requirements.

In automotive oil filters, papers provide a high degree of filter efficiency at a low enough cost to permit "throw-away" units. In air filtration, papers have replaced the older metal wire-oil bath filters, because they maintain a constant efficiency. The efficiency of the older filters was dependent to a degree on the oil bath level which changed as the car went up or down hills.

Papers are being used in many other types of air filtration, ranging from room air conditioners to industrial plant filtration. An example of a specially developed filter paper is an asbestos paper developed during World War II to collect radioactive dusts and other air-borne particles to test air contamination. The material was supplied with closely controlled mechanical strength, surface fuzz, caliper and air resistance, and with a silicone treatment to make the sheet water repellent.

Inorganic fiber papers can be used for extremely high temperature filtration. Such papers can be made of asbestos, some types of glass or aluminum silicate fibers. Since these fibers do not felt together as cellulose fibers do, binders are usually used to provide strength. Where maximum heat resistance is required, strength requirements must be relatively low, since most binders are limited in heat resistance.

Many vacuum cleaner bags are now made of papers. The main requirements are a combination of strength and high solids retention, while permitting maximum air flow. Many such bags are made of rope fiber paper, since the longer fibers provide higher strength and flexibility at higher flow rates.

Filter papers are also used for tea bags and for filtering media for coffee and edible oils in cooking. They can also be used for a variety of other filtration applications, such as filtration of machine cooling oils or hydraulic fluids, and domestic hot water.

How to Specify Paper

Because of the versatile nature of papers, there is a lack of standard grades and published specifiable properties. Thus close cooperation of the paper manufacturer or converter is usually mandatory.

In most cases, the following procedure can be used as a guide to selecting a paper and developing specifications for it:

1. Investigate paper during the initial materials evaluation period for any given design if there is any possibility at all that a paper material might meet the design requirements.

2. Draw up a list of both mandatory and desirable requirements of the design in question, including mechanical, physical, environmental and aesthetic factors, as well as production volume anticipated and other economic considerations. These usually should not be worked up into detailed specifications until the paper manufacturer or converter has been consulted.

3. Submit this list of requirements to a reputable paper manufacturer or converter specializing in the type of paper form you are likely to require. (A comprehensive list of paper manufacturers and converters can be found in *Lockwood's Directory of the Paper, and Allied Trades*, Lockwood Trade Publishing Co., New York.)

4. The manufacturer or converter will then either 1) submit samples for test, or 2) where a special type of paper is required and volume or potential market warrants, suggest that a special paper be developed to suit the design needs. In the latter case, the paper manufacturer or converter will work closely with you in developing final specifications.

5. After testing samples supplied by manufacturer, inform him which samples are most suitable and in what ways, if any, they fail to meet the design requirements.

6. The producer will then work in detail with you in working up specifications based on standard American Society for Testing Materials or Technical Association of Pulp and Paper Industry test methods.

Gasketing

Papers are used for both light and heavy-duty gasketing. Common property specifications for such papers are compression and recovery, dimensional stability, tensile strength, bursting strength, crush resistance, impermeability and resistance to oils, gasoline, water, or other environments. An accompanying box indicates the variety of types of papers used for gasketing in car manufacture.

A number of specialty paper materials have been developed to provide specific gasketing benefits. Most such specialty papers are beater saturated materials (i.e., non-fibrous additives mixed with the pulp at the beater stage). Though proprietary types differ in composition, materials include cellulose or asbestos fiber papers saturated with natural or various synthetic rubbers such as neoprene, nitrile or butyl, or synthetic resins. In some types, cork has been added for increased compressibility.

In addition to relatively non-critical gasketing applications, papers can be used for gasket and sealing conditions such as high and low pressure steam and water, relatively high and low temperature water and oil, aromatic and non-aromatic fuel systems, and for sealing both rough and machined surfaces.

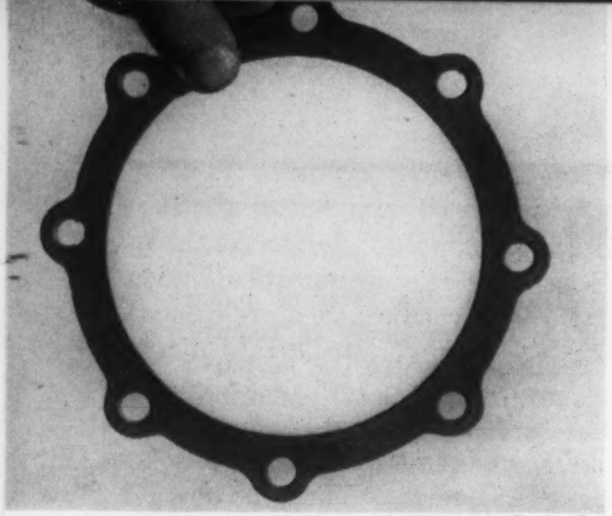
Asbestos or aluminum silicate ceramic fiber papers can be used for gasketing pressure vessel flanges, orifice blocks and other equipment operating at high temperatures and relatively low pressures. Because of its high porosity, aluminum silicate paper can be impregnated with silicones, fluorocarbons and similar heat resistant impregnants to adapt it to higher pressure gasket applications.

Electrical insulation

Electrical insulation of a variety of types represents one of the largest engineering uses of papers. Following is a general classification of the most commonly used electrical insulating papers:

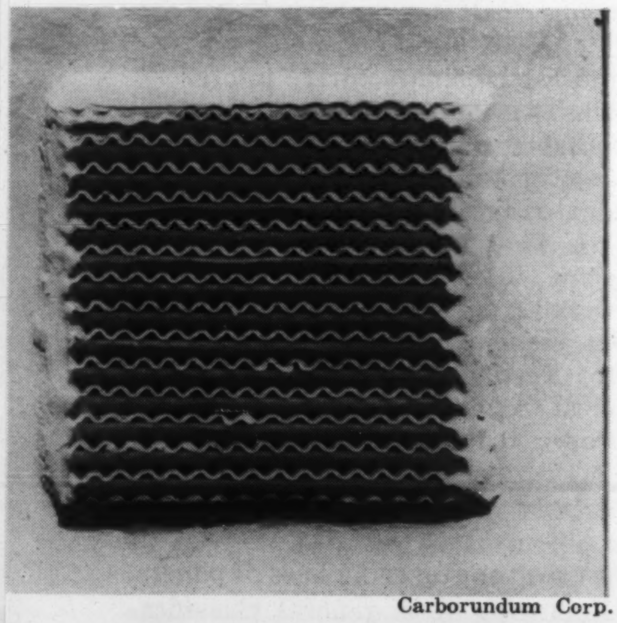
Coil paper, often described as layer insulation, has high dielectric strength and is used between layers of wire in transformers or as wrap-around insulation. It is usually a kraft paper, flexible and free from metallic or other conducting particles, and having uniform thickness and high dielectric strength. Usual thickness range is from 0.005 to 0.030 in.

Cable paper, or turn insulation, is a paper suitable for insulation on wire or cable. Usually made from manila rope or sulfate pulp, thicknesses generally range from 0.0006 to 0.0085 in. It should be free from foreign materials, have high dielectric strength, low power factor, high machine direction tensile strength and cross-machine



Armstrong Cork Co.

Gasketing *papers are available for service in a variety of fluids and at relatively high temperatures and pressures. Gasket shown is a beater saturated paper, combining cellulose fibers with finely ground cork and a nonvolatile nitrile rubber, for sealing hot oil at temperatures up to 300 F. It has high compressibility, for sealing rough cast flanges.*

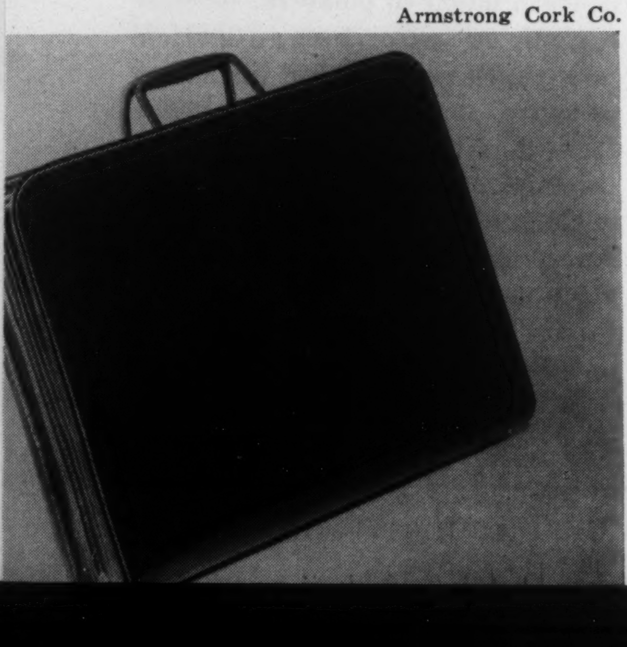


Carborundum Corp.

High temperature filtration *of gases in this unit is carried out through the corrugated aluminum silicate fiber paper, pleated for maximum filter area and cemented to the aluminum silicate frame.*

Simulated leather, *consisting of leather fibers beater-saturated with rubber is said to provide greater uniformity and moisture resistance, greater strength and longer life than genuine leather.*

Armstrong Cork Co.



tear strength, and good stability under conditions of dry heat and treatment with insulating liquids.

Crepe paper is used for taping coils, leads and insulating pads. Its high degree of conformability aids wrapping around corners and odd shapes.

Capacitor paper is used as a dielectric between foils of insulating liquid-filled condensors. It is usually made from sulfate or hemp pulp and is used in thicknesses of 0.0002 to 0.001 in. Important properties are chemical purity, uniformity of thickness, good formation and freedom from foreign matter, particularly conductive particles. For alternating current capacitors, low power factor characteristics are important; for direct current, high insulation resistance is important.

Condenser paper, usually made from sulfate, though some is made from cotton or hemp pulp, is used as a spacer between foils of electrolytic capacitors. Thicknesses range from about 0.0006 to 0.004 in. Important properties are porosity, absorption of electrolytic liquids and chemical purity (particularly freedom from soluble chlorides).

To obtain other particularly desirable properties not inherent in the paper, papers may be 1) impregnated with resins, varnishes, waxes and dielectric liquids; 2) coated with resins, varnishes, acetate, adhesives, waxes and shellac; or 3) laminated with other papers or with plastics films or metal foils.

High temperature insulating papers can be made of asbestos, glass or ceramics. Asbestos insulating paper is usually made of of specially processed white asbestos fibers in thicknesses of 0.003 to 0.009 in. The paper can be treated with resins and laminated to improve its mechanical properties.

Glass papers can also be used for Class H high temperature service. Usually they are impregnated with silicone resins to provide additional strength. Aluminum silicate papers, because of their combination of high temperature resistance and good dielectric characteristics also look promising for high temperature electrical insulation.

Other insulation

The felted, fibrous structure of papers makes them good absorbers of heat, sound and vibrations. Probably the most commonly used paper for this type of application is asphalt saturated felt paper used in automobile manufacture to dampen vibrations between metal panels and to provide thermal and acoustical insulation inside such areas as trunk compartments and motor hoods.

Papers are also commonly used as thermal insulation and vapor barriers in refrigerator wall construction. Refrigerator felts usually consist of two or more sheets of kraft paper, treated to make them impervious to moisture, then creped and laminated with asphalt.

For higher temperature thermal insulations—hot pipes, air conditioning ducts, fire walls and hot water heater jackets—asbestos papers are suitable. Aluminum silicate fiber paper can be used to line metal ducts, ladles, spouts and other metal components used to handle molten nonferrous metals, since such metals do not readily wet or attack the fiber. The paper can also be used as a lining for combustion chambers in oil fired heating units to protect the steel wall of the chamber from direct flame impingement.

Structural components

Although by usual engineering standards, paper is not generally a very rigid or strong material, paper structures can be engineered into remarkably strong structural members.

Sandwich construction, using paper as the honeycomb core and either paper or other materials as the faces, is a well-known structural material. Phenolic-impregnated kraft papers are widely used as core materials. Typical properties of a core made of a 70 lb impregnated kraft paper with an 0.437 in. cell pitch across the corrugation is: density, 2.18 lb per cu ft; crushing strength,

Typical Automotive Gasketing Papers

Plant fiber papers

UNTREATED PAPERS

1. Tag stock.
2. Vegetable fiber — including 1) 100% rope, 2) rope and chemical wood pulp, 3) chemical wood pulp, 4) mechanical wood pulp, and 5) rag pulp.
3. Vegetable parchment.
4. Chipboard—including plain and manila lined.
5. Fiber board, unvulcanized.

TREATED PAPERS

1. Gelatin and/or synthetic resin impregnated plant fiber—including high, medium and low oil, water and gasoline resistant grades.
2. Gelatin and/or resin impregnated compositions (fibers may be of wood, cork, leather, etc.)—including high, medium and low oil, water and gasoline resistant grades.
3. Natural and/or synthetic rubber impregnated fiber (includes beater saturated types)—includes maximum, good and fair oil and aromatic fuel resistant grades, and good water resistant grades.
4. Natural and/or synthetic rubber impregnated compositions (fillers may be wood, cork, leather, etc.)—includes maximum, good and fair oil and aromatic fuel resistant grades, and non-oil resistant grades.

Asbestos fiber papers (selected fiber)

1. Untreated papers—includes general purpose, and eight weights ranging from 8 to 64 lb per 100 sq ft.
2. Treated papers — includes general purpose board and three grades ranging from 16.5 to 27.0 lb per 100 sq ft.
3. Millboard.

Source: Adapted from *General Motors Approved Standards;* Vol. II, "Materials and Processes." This listing is not intended to imply that all of these papers are being used at present, but indicates the types for which specifications have been prepared.

140 psi; shear strength (long direction), 85 psi; and modulus of rigidity (long dir), 9000 psi.

Paper honeycomb cores can be be further strengthend by filling the air spaces with a plastic foam. Use of metal or reinforced plastics facing materials also improves strength. A typical one-inch thick sandwich material, consisting of paper honeycomb core faced with 0.016-in. aluminum sheets, has an EI rigidity factor of 792,000, and weighs only 0.75 lb per sq ft. (For more information see "Phenolic-Impregnated Paper Forms High Strength Low Weight Honeycomb," MATERIALS & METHODS, July '55, p 98).

Fiberboards, which are made on wet machines from chemical wood pulp, waste papers, other waste materials or a combination of such materials, can be used for various semi-structural applications, such as luggage or containers. Fiberboards can also be used in parts for refrigerators, air conditioners, washers and dryers and other home appliances. In many cases they can be used to replace metal or plastic panels at lower unit cost and with no sacrifice in quality.

Backing and simulated materials

A major application for papers is as backing material for decorative films or other surfacing materials. Usually saturating papers, impregnated with resins or elastomers are used, with vinyl or other types of plastics films laminated to the surface. Such compositions are used for a variety of artificial leather products, ranging from belts and wallets to cigarette cases and desk accessories. The paper provides bulk and depth to the product and, in many cases, replaces fabrics and reduces cost.

Simulated leathers can be made of materials which are essentially papers. One such beater saturated paper consists of leather fibers bonded with a synthetic rubber. The material is said to closely resemble natural leather, but is more uniform and more moisture resistant.

Twine, yarns and textiles

Twisted paper twine or yarn can be used in a variety of applications such as yarns for auto seat covers or trunk linings, luggage covers, handbags, carpet or rug backing, imitation reed furniture and upholstery trimming, or cords for cable fillers.

Properties of paper

Because of the nature of paper, many of its properties, tests used to measure them, and values in which they are expressed differ radically from those commonly used for other engineering materials. An understanding of these properties and tests is of great help in working intelligently with the paper supplier to select and specify the type of paper required.

The following discussion explains some of the most important properties of papers as engineering materials, as defined by the standard test methods of the Technical Association of the Pulp and Paper Industry (TAPPI) and American Society for Testing Materials (ASTM). The properties have been selected as the most meaningful for engineering applications of paper. There are many other properties which do not appear here because no standard test method has been established. In most of these cases, individual users have developed tests to describe these properties under conditions important to their specific use.

In the following sections parenthetical numbers prefixed with the letter *T* refer to TAPPI standards; numbers prefixed with the letter *D*, *C* or *E* refer to ASTM standards. Where both TAPPI and ASTM designations are given, the designations refer to test methods which agree in substance, but which may differ in some particulars. No indication is given here as to whether designated standards are *official standards*, *tentative* or *suggested methods*.

As is the case with most sheet materials, papers usually have a degree of orientation in the web. Usually fibers are oriented predominently in the machine direction, thus for most tests, results must be given both in the machine and cross (machine) direction.

Descriptive properties

Basis weight—Weight, in pounds, of a ream of 500 sheets of a given size (T 410; D646). Standard sheet size for comparison of physical properties is 25 x 40 in. Some countries use reams consisting of 480 sheets, and the U.S. Government Printing Office uses a unit of 1000 sheets. Basis weight of paperboards is expressed in pounds per 1000 sq ft.

Results of basis weight determinations are required to be given in at least two of the following ways: 1) equivalent basis weight, in pounds, for a ream consisting of 500 sheets, 25 x 40 in. in size, 2) weight, in grams per square meter, or 3) equivalent weight for the ream size commonly used in the paper industry for that particular kind of paper.

Basis weight is commonly expressed in several ways, e.g., 1) *20 lb,* meaning a ream of 500 sheets, 25 x 40 in., weighs 20 lb or 2) *20 lb (17 x 22-500)* or *17 x 22-20/500,* either of which means that a ream of 500 sheets, measuring 17 x 22 in. weighs 20 lb.

Thickness and density—Thickness is expressed in thousandths of an inch (referred to commonly as points), determined on a large micrometer (T 411; D645).

Specific volume (SV) and density (D) are calculated as follows:

$$SV = \frac{T_2}{W_2} = \frac{T_1}{W_1} \times 18.08$$

$$D = \frac{1}{SV}$$

How Paper Is Made

All papers are produced from crude fibrous pulps. Since wood pulps are used for making most papers the discussion here is concerned primarily with those types.

Types of wood pulps

The type of pulp from which a paper is made to a large extent determines the type of paper produced. Wood pulps can be classified generally as follows:

Mechanical wood pulps—Pulps produced by mechanical processes are of three major types:

1. Groundwood—Used in a number of papers where absorbency, bulk, opacity and compressibility are primary requirements, and permanence and strength are of minor importance.

2. Defibrated—Used for insulating board, hardboard or roofing felts, where good felting properties are required.

3. Exploded—Used for building and insulation hardboards (see "Wood Composition Boards," MATERIALS & METHODS, Aug '57, p 107).

Chemical wood pulps—Pulps produced by "cooking" in various chemicals are used in practically all grades of paper and many grades of board. Chemical pulps are of six major types:

1. Sulfite—Used in the bleached or unbleached state for papers ranging from very soft or weak to strong grades. There are about 12 grades of sulfite pulps.

2. Neutral sulfite or monosulfite—Used for strong papers such as bags, wrappings and envelopes.

3. Sulfate or kraft—Provides high strength, fair cleanliness and, in some instances, high absorbency; used for strong grades of unbleached, semibleached or bleached paper and board.

4. Soda—Used principally in combination with bleached sulfite or bleached sulfate pulp for book printing papers.

5. Semichemical — Used primarily for specialty boards, corrugating papers, glassine and greaseproof papers, test liners and insulating boards and wallboard.

6. Screenings — Used principally for coarse grades of paper and board such as millwrapper, and as a substitute for chipboard, corrugating papers and insulation board.

Stock preparation

The several operations through which the pulp must go before it is formed on the papermaking machine can have a further effect on the paper's properties.

Beating and refining—The purpose of beating is to "fluff" out the fibers and to transfer hydrogen bonds from within fibers to between fibers permitting them to interlock to a greater degree within the paper; refining cuts the fibers into shorter lengths providing better distribution of fibers throughout the paper web. Beating effects almost all mechanical properties of paper. Longer beating times usually tend to increase tensile strength, burst strength, density, folding endurance, stiffness, transparency and other properties. Except in the initial stages, extending beating time tends to decrease tear strength.

Curlation—A machine called a curlator can be used where specific properties, such as in-where:

T_1 = thickness, mil
T_2 = thickness, μ
W_1 = basis weight, lb
(25 x 40-500)
W_2 = basis weight, gm/sq m

Opacity—Opacity is that property of a paper which prevents dark objects on, or in contact with, the back side of the sheet from being seen. It is evaluated by contrast ratio, calculated as a percentage figure; the higher the value, the more opaque the paper (T 425; D590).

Surface appearance — Several tests measure the brightness or degree of reflectivity of paper surfaces.

1. *Reflectivity* of a sheet of paper for blue light, reported in percentage brightness in comparison with magnesium oxide taken as 100 (T 452; D985).
2. *Spectral reflectivity and color* of paper, reported as spectral reflectivity of the sample relative to that of magnesium oxide (T 442).
3. *Forty-five degree and zero degree directional reflectance* for blue light, reported in percentage directional reflectance (D 985).
4. *Gloss* is the geometrically selective reflectance of a paper surface responsible for its shiny or lustrous appearance. For low gloss papers contrast gloss at 57.5 deg (T 424; D1222) is reported as percentage gloss; for high gloss papers specular gloss at 75 deg (T 480; D1223) is reported as average gloss value.

Strength properties

Tensile strength—Expressed in pounds per inch width in both machine and cross directions, tensile breaking strength (T 404; D828) is the average tensile stress required to completely rupture rectangular samples of specified dimensions. The apparatus is a usual pendulum type.

Wet tensile strength—Wet tensile breaking strength (T 456; D829) is the average tensile stress required to completely rupture rectangular samples after complete saturation with water. Complete saturation is determined by trial tensile tests after soaking samples in distilled water for increasing periods of time. Immersion time after which minimum rupture stress values are obtained during trials should be used as minimum immersion time for

creased tear strength, bulk, brightness and an even textured matte appearance are desired. The curlator actually curls and crinkles the fibers and breaks up any fiber bundles.

Beater additions—A wide variety of nonfibrous materials can be added in the beating stage to obtain certain properties in the paper. Probably the most common conventional additives are: 1) Sizes, usually used to impart water resistance. 2) Mineral fillers, usually used to increase paper opacity, improve printing properties, increase brightness and control combustion; fillers also reduce water resistance, soften the paper and can reduce the cost of raw materials. 3) Starch, which can be used to increase bursting and tensile strength, increase stiffness and "rattle," and improve finish. 4) Silicate of soda, which can improve finish, strength, firmness and color, as well as serving as a sizing. 5) Wet strength resins, such as urea or melamine, which improve wet strength as well as folding endurance; tear strength may be impaired in some cases. 6) Coloring dyes or pigments.

Papermaking

The two basic types of papermaking machines are the Fourdrinier and the cylinder machines. The Fourdrinier is the most commonly used. Though such machines are custom-built for each producer, the general principles are the same.

Fourdrinier papermaking—The pulp, mixed to a consistency of 97.5-99.5% water, is fed continuously to the Fourdrinier, which consists of an endless belt of fine mesh screen called the "wire." The wire is usually agitated transverse to the travel direction, helping the fibers to crisscross, felt and mat together. Such shaking also provides a degree of isotropic orientation. Usually, however, fibers are predominantly oriented in the machine direction, resulting in anisotropic strength characteristics in the final paper.

While the water saturated pulp is traveling along the Fourdrinier wire, water drains through the screen and is drawn into suction boxes placed at several points under the wire. A so-called dandy roll is sometimes positioned above the first suction box, to smooth the "felt side" of the paper.

When the paper web leaves the Fourdrinier wire, it usually contains about 83% water. It then passes through presses, and usually a variety of other types of equipment, such as dryers and calender rolls, depending on the type of paper being produced.

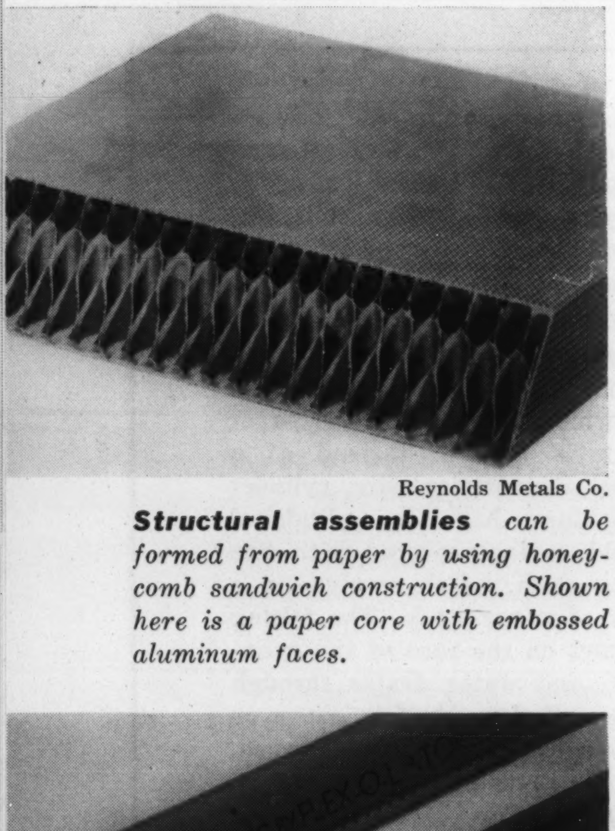
Cylinder machine papermaking—A cylinder machine differs from a Fourdrinier machine in the method by which the paper web is formed. Instead of a level Fourdrinier wire, cylinder machines have a cylindrical mold surface covered with fine wire cloth, which revolves in a vat of paper stock. The felting occurs on the face of the cylinder, and water drains through the cylinder. A felt conveyor carries the web, thus formed, to the press and dryers.

A greater variety of thicknesses of paper can be produced on a cylinder machine than on a Fourdrinier. Thicknesses can range from the thinnest tissue to the thickest building board. Instead of one cylinder, a number of cylinders can be arranged in tandem, the wet paper web from each cylinder picking up the wet web from the following cylinder, forming a number of plies. After pressing and drying, the various plies are strongly laminated together.

final testing. Final testing is carried out by the same procedure as specified for T 404 and D828.

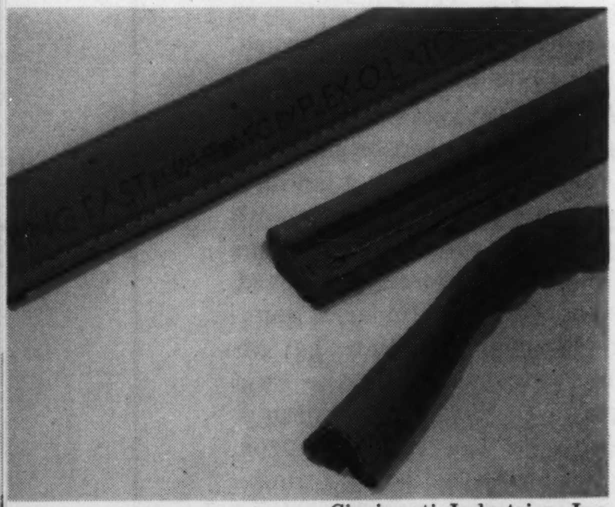
Stretch—Stretch in paper, reported as percent increase of sample length between the clamps after complete rupture, is somewhat comparable to elongation in other materials. It is determined on an apparatus similar to that used for tensile testing, except that 1) a means of applying a predetermined initial tension to the specimen and 2) a means of indicating elongation of the specimen up to the instant of complete fracture, are provided (T 457; D987).

Stretch in paper differs from elongation in other materials in that the numerical results obtained include not only both elastic and inelastic stretch, but also the small distance through which the broken strip elongates while being held together by protruding fibers. Thus, the stretch property might be thought of more correctly as "percentage elongation up to and partly including rupture in tension."



Reynolds Metals Co.

Structural assemblies *can be formed from paper by using honeycomb sandwich construction. Shown here is a paper core with embossed aluminum faces.*



Cincinnati Industries, Inc.

Edge roll binding, *used in furniture manufacture makes use of cross-creped kraft paper, which can be stitched and provides substantial economies.*

Bursting strength (Mullen)—Expressed in pounds per square inch, or "points," the test is usually made on a Mullen Tester and is the hydrostatic pressure required to rupture a piece of paper (T 403; D914). The test device consists of a metal ring and a metal ring clamp holding the paper specimen over a rubber diaphragm, which covers a pool of liquid. During testing the diaphragm is forced up against the paper by exerting increasing pressure on the liquid, until the paper bursts.

Tearing strength—There are two standard tear strength tests and one non-standard.

1. *Internal tear resistance* (T 414; D689) determines the force, in pounds, required to tear a single sheet of paper after the tear has been initiated by slitting the sample (Elmendorf type apparatus).

2. *Edge tearing resistance* of paper (T 470) determines the force, in pounds, required to tear a single sheet of paper from the unslitted edge (Finch method). It is carried out by fitting a standard tensile tester with a stirrup and a thin v-notched beam over which the specimen is threaded, both ends of the specimen being held in the same clamp. The beam, when sufficient stress is applied, causes the paper to tear at both edges of the specimen.

3. *Initial tearing strength* is a non-standard term used to express the resistance of paper to tearing at the edge of a sheet. It is commonly evaluated by sensing this resistance when a tear is started from the edge by application of a twist or force using the thumbs and index fingers.

Compressive strength—Generally, compressive strength of paper, expressed in pounds, is a measure of a paper's ability to resist a crushing force applied at the edge, in a direction parallel to the plane of the paper, under specified conditions.

The only standard method, the Ring Crush Test (T 472; D1164), is intended only for paperboard less than 0.030 in. thick, and its primary purpose is to determine the suitability of board for packaging. The test results indicate the total load required to crush a cylinder of paper of a specified diameter.

Ply adhesion — Expressed in pounds per inch of width, it is a measure of the amount of bond or adhesion between plies of multi-ply papers, such as those produced on cylinder machines (D825). Test results are useful in determining how well the various plies will adhere to one another. Poor adhesion may cause the plies to separate in service, destroying the sheet.

The test can be carried out on a special device commercially available (Method A) or on a standard paper tensile tester (Method B). Separation of the plies of samples of specified dimension is begun by hand as near the center ply as possible. The two sheets thus separated are inserted in the jaws of the test device, and peel stress is applied. Maximum, minimum and average ply adhesion, as well as the method used, is reported.

Flexural properties

Folding endurance—This is a measure of the capacity of a paper to be folded over itself many times without failure. Expressed in number of double folds required to sever the specimen, it can be determined either on a Schopper or an M.I.T. Fold Tester (T 423; D643). Because there is no constant relation between test values obtained with the two testers, the instrument used must be reported.

A test for determining the effect of heat on folding endurance (D776) reports percent retention of folding endurance after 72 hr exposure to 220 F. Testing after the specified exposure is carried out in the same manner as specified in T 423 or D643.

Rigidity, stiffness and softness of papers and paperboards—This test (T 451) measures a) resistance of papers to an applied bending force, or flexural resistance; this is proportional to *EI*, b) rigidity factor, which is proportional to the modulus of elasticity, *E*, or modulus of rigidity, which is a measure of the rigidity of the internal structure of the sheet, c) stiffness, or the ability of paper to support its own weight; this is proportional to *EI/W*, where *W* is the basis weight, and d) softness, which is the feeling of softness when a sheet is crumpled in the hand; this depends on ease of crumpling, together with the absence of sharp edges in the crumpled sheet. Softness is inversely proportional to the rigidity, *EI*, modified by a function of the sheet thickness.

The apparatus consists of clamps mounted on a spindle which can be rotated on a horizontal axis. The end of the specimen, which is over 3 in. long, is clamped with enough overhang above the clamp so that when the spindle is rotated clockwise, the specimen (originally positioned so that the overhang was to the left) flops up through the vertical to the right, and on rotating the spindle back counterclockwise through a 90 deg angle the strip does not fall back to the left side. The overhang is then reduced until a slow rotation of 90 deg clockwise and counterclockwise causes the end of the strip to fall from one side to the other.

The critical length (length of the specimen from clamp to end) is then measured. Rigidity, rigidity factor, stiffness and softness are then calculated by the following formulas:

$$\text{Rigidity} = \frac{L^3W}{10{,}000}$$

$$\text{Rigidity factor} = \frac{L^3W}{100\ T^3}$$

$$\text{Stiffness} = \frac{L^3}{100}$$

$$\text{Softness} = \frac{1{,}000{,}000 \log (t+1)}{L^3W}$$

where:
L = average critical length, cm
T = thickness of a single sheet of paper, thousandths of an in.
t = basic thickness of a single sheet of creped paper, thousandths of an in.
W = basis weight, gm per sq m

Flexural resistance and deflection of insulating fiberboard—Though originally intended for architectural fiberboards, this test (T 1003) can be modified for testing rigid insulation boards used for engineering purposes.

The test consists of center-point loading, in a modified tensile or compression tester, a span equal to 24 times the thickness of the board. The loading head and supports are three times the thickness of the board. Transverse strength of the board in each direction is reported in pounds per square inch. Deflection for each direction is reported in inches.

Modulus of rupture can be calculated from the equation:

$$R = \frac{1.5PL}{wt^2}$$

where:
R = modulus of rupture, psi
P = maximum load at failure, lb
L = length of span, in.
w = width of specimen, in.
t = thickness of specimen, in.

Effects of moisture

Water resistance—Water resistance of paper (Dry Indicator Method T 433; D779), is reported as the maximum, minimum and average time, in minutes or hours, for water to pass through a specimen of paper as determined by the discoloration of an indicator material.

The apparatus meets the following conditions: 1) one surface of the specimen is wetted uniformly at the moment the time count is begun, 2) the indicator on the opposite surface is continuously visible, 3) no moisture reaches the indicator except that which passes through the specimen from the wetted surface, and 4) no moisture which reaches the indicator escapes contact with it.

Surface wettability—A measure of the resistance of the surface of a paper to wetting. The Angle of Contact Method (T 458; D724) measures the angle of contact between the drop of water and the surface, as well as the rate at which the drop spreads on the surface. With a suitable specified device which magnifies the image of the drop of water on the test specimen onto a sheet of tracing paper attached to a frosted glass screen, tangents are drawn to the curve of the drop at the point of contact with the test paper. Initial wettability is reported as the average angle of contact after five seconds exposure, and rate of wettability change is calculated as follows:

$$R = \frac{A - a}{55}$$

where:
R = rate of wettability change, deg per sec
A = average angle of contact after 5 sec, deg
a = average angle of contact after 60 sec, deg

While this test is useful for determining writing and ruling qualities of papers, it can also be useful for other problems related to the use of papers where wet conditions are anticipated.

Moisture content—Two methods are available for determining moisture content of papers.

1. Moisture content determinations by the first type of test (T 412; D644) can be applied to all paper, paperboard and paper products except those containing significant quantities of materials other than water which are volatile at 220 F (for such materials see the second method below). Moisture content, expressed in percent loss in original weight, is determined by weighing the specimen before and after oven drying at 220 F for about 2 hr.

2. Moisture content determinations by toluene distillation (T 484) is useful as a rapid and accurate method for determining moisture content in comparatively small samples. It is not intended for use with ordinary papers in place of T 412, but rather for use with specialty papers such as waxed and varnished papers, where moisture cannot be determined by the oven-drying method due to the presence of fusible constituents or the probable loss of

volatiles. In this test method, water is distilled from the sample and condensed in a trap. Test results are given as a calculated percent moisture of original weight of sample.

Water absorption—Two tests are available for determining water absorptiveness of papers; one for use with papers of relatively high absorptivity (bibulous) and one for papers of relatively low absorptivity (nonbibulous).

1. Water absorptiveness of bibulous papers (T 432; D824) is intended for use only with unsized, absorbent papers. Absorptivity is reported as amount of test liquid absorbed, and minimum, maximum and average time of absorption when liquid is added by pipet to the surface of the paper. Absorption time is measured by time required for water to be completely absorbed as indicated by no further reflection of light from it when viewed at an angle.

2. Water absorptiveness of nonbibulous paper and paperboard (T 441) is used for determining water penetration into paper and paperboard 0.004 in. and greater in thickness. It can be used in all cases except where resistance to penetration is due to the resistance of the surface film to minute quantities of water.

The test involves applying water to a controlled area of a preweighed sample for a given period of time (depending on the type of paper). At the end of the test period, water is removed from the surface of the paper, and the specimen is weighed. Results are given in grams per square meter, calculated as follows:

$$A = 10{,}000\ \frac{W}{S}$$

where:

A = absorptiveness, gm/sq m

W = difference between final weight and original weight, gm

S = diameter of the test area, sq cm

Moisture expansivity—Paper is relatively sensitive to moisture, and with increasing or decreasing moisture content, it expands or contracts. Moisture expansivity determinations (T 447) indicate the percent change of length of a sample for a decrease of 15% relative humidity (from 65 to 50%). Test consists of placing a sample of specified dimensions in a humidity cabinet and measuring the changes in length either by optical lever or any method of equivalent accuracy.

Water vapor permeability—Water vapor permeability is defined as the weight of water transmitted per unit of time per unit area when one face of the paper is exposed to moisture free air and the other is exposed to 1) a standard atmosphere (T 448; D988), 2) tropical atmospheres (T 464; D988), or 3) a temperature of zero F (T 482).

Determinations are made by placing a desiccant in a test dish and sealing the top of the dish with a sample of the paper to be tested. Dishes are weighed and exposed to the condition for which water vapor permeability is to be made (1, 2, or 3 above). Dishes are weighed at suitable intervals until a constant rate of gain is obtained.

Water vapor permeability is reported as 1) oz/100 sq yd/24 hr at either 73 F, 100 F, or zero F, and 2) at the humidity gradient defined in the test.

Water vapor transmission — Water vapor transmission determinations, reported in gm/24 hr/sq m, can be made by the standard test (E96) used for testing sheet materials such as plastics film.

Other properties

Thermal conductivity—Thermal conductivity of structural insulating board reported in Btu/sq ft/hr/°F/in., (T 1000) is essentially the same as the standard guarded hot plate method (C 208). The TAPPI test description has been somewhat condensed for application to flat slabs of homogeneous structural insulating board as defined by all classifications of Commercial Standards CS-42 and CS-112, ASTM C 208 and Federal Specification LLL-F-321b.

Flammability of treated papers —Test method (T 461; D777) is applicable for determining resistance to flame of papers and paperboards not over 1/16 in. thick which have been treated to prevent spread of flame when ignited.

Samples of specified dimensions are supported vertically in a frame and ignited at the center of the bottom edge. Flame is applied for 12 sec, then withdrawn. Results are reported as 1) char length, or average maximum height of charred or burned area, in inches, and 2) afterglow, or the average time, in sec, that the specimen continues to glow after the burner flame is removed.

Acknowledgments

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American Paper and Pulp Assn.
American Sisalkraft Corp.
Armstrong Cork Co.
Brown Co.
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Case Bros., Inc.
Cellusuede Products, Inc.
Cincinnati Industries, Inc.
Clupak, Inc.
Dennison Mfg. Co.
E. I. du Pont de Nemours & Co., Inc.
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Hollingsworth and Vose Co.
International Paper Co.
Johns-Manville Corp.
Keasbey & Mattison Co.
Kimberly-Clark Corp.
Knowlton Bros.
J. P. Lewis Co.
Mosinee Paper Mills Co.
National Filter Media Corp.
Plymouth Cordage Co.
Raybestos-Manhattan, Inc.
Riegel Paper Co.
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Ruberoid Co.
Scott Paper Co.
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St. Regis Paper Co.
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West Jersey Paper Mfg. Co.
West Virginia Pulp and Paper Co.

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FILE FACTS

Cast Leaded Tin Bronzes

BBII Grade ➡	2A	2B	2C
COMPOSITION, %	Cu 88, Sn 6, Pb 1.5, Zn 4.5	Cu 87, Sn 8, Pb 1, Zn 4	Cu 87, Sn 8, Pb 1, Zn 2
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.311-0.318	0.314-0.320	0.314-0.320
Melting Temp Range, F	1830	1830-1570	1830-1570
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	28	28
Coef of Ther Exp (70-350 F), per °F	10.3×10^{-6}	10×10^{-6}	10×10^{-6}
Electrical Conductivity (68 F), % IACS	14	11	11
MECHANICAL PROPERTIES[a]			
Mod of Elast in Tension, psi	$12\text{-}16 \times 10^{6}$	$10.6\text{-}16 \times 10^{6}$	$10.6\text{-}16 \times 10^{6}$
Tensile Strength, 1000 psi	36-48	33-43	36-46
Yield Strength (0.5% ext), 1000 psi	16-21	16-24	18-26
Elongation (in 2 in.), %	25-40	18-30	15-25
Reduction of Area, %	16-33	15-30	12-26
Hardness (Brinell)	60-72	60-75	65-80
Impact Strength (Izod), ft-lb	11-16	12-15	7-10
Compressive Yield Strength (0.001-in. set), 1000 psi	12-15	9-11	12-14
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000-2300	2100-2300	1200-2300
Heavy Castings	1900-2150	1920-2100	1920-2100
CORROSION RESISTANCE	Generally the same as nonleaded alloys of similar composition		
USES	Oil pumps, gears, bushings, high duty bearings, ornamental bronze	General utility structural bronze, pipe fittings, expansion joints, pressure valves and fittings	Bolts, nuts, gears, valves, pump pistons, pressure pipe fittings, expansion joints

[a] Values are given for the as-cast condition.

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Stress Corrosion Failure Checked in New Aluminum Bronze Alloy

■ Aluminum bronze alloys have long been known to possess outstanding corrosion resistance and relatively high strength. However, spontaneous cracking failures in the presence of steam (stress corrosion cracking) has heretofore limited their usefulness in many applications for which they would otherwise be ideal. Now, however, a new aluminum bronze alloy is available which is said not only to completely overcome stress corrosion failure, but to maintain a high degree of strength and corrosion resistance up to 500 F.

The new copper alloy contains 6.5 aluminum, 2.3 iron, 0.25 tin and 0.25% of other elements (silver, nickel and manganese). According to Ampco Metal, Inc., Milwaukee, Wis., it is the addition of 0.25% tin to the analysis that prevents stress corrosion cracking. As a result, it is no longer necessary to stress relieve finished fabrications. Also, alterations, repairs or field changes can now be made without stress relieving.

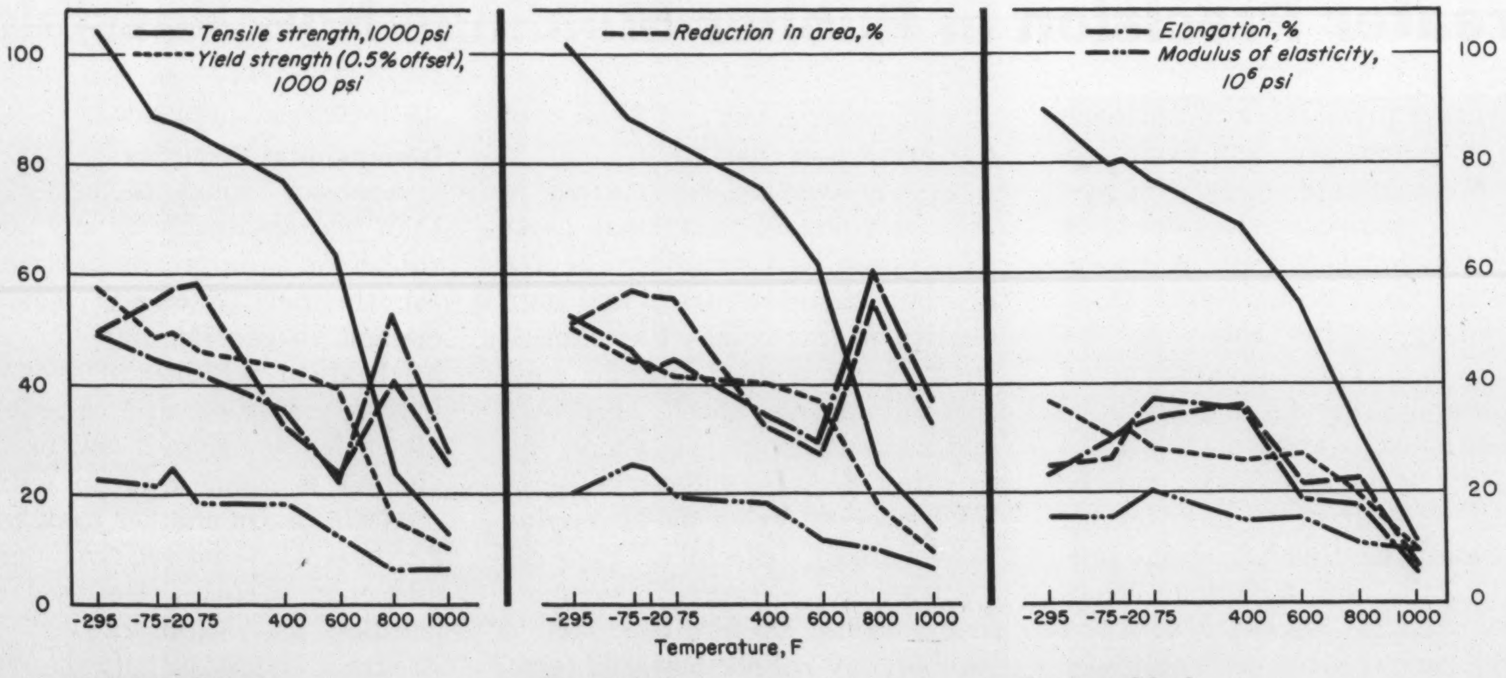
MECHANICAL PROPERTIES OF AMPCO 8

Form ➜	Sheet (⅛ in.)	Plate (½ in.)	Rod (1 in.)
Ten Str, 1000 psi	82	78	82
Yld Str, 1000 psi	45	35	55
Elong, %	40	42	35
Hardness			
Rockwell B	84	—	—
Brinell	—	153	179

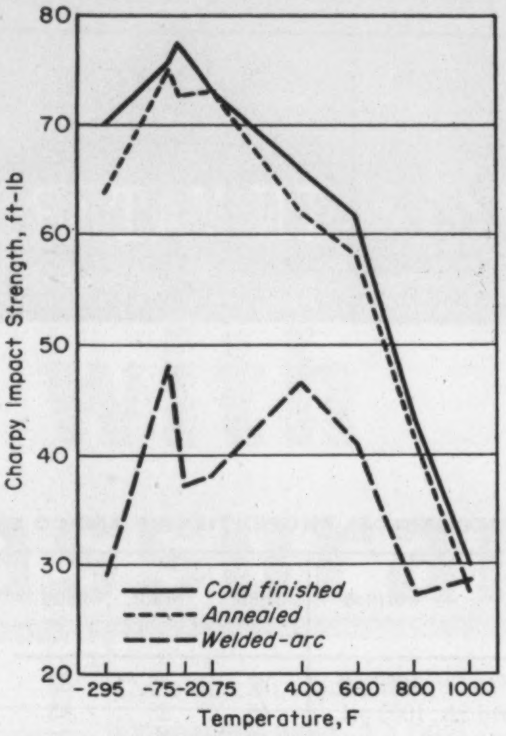
Stress corrosion cracking

According to J. F. Klement, director of Ampco research, stress corrosion cracking occurs in an alloy because of the atomic segregation of solute elements at the grain boundary. This segregation

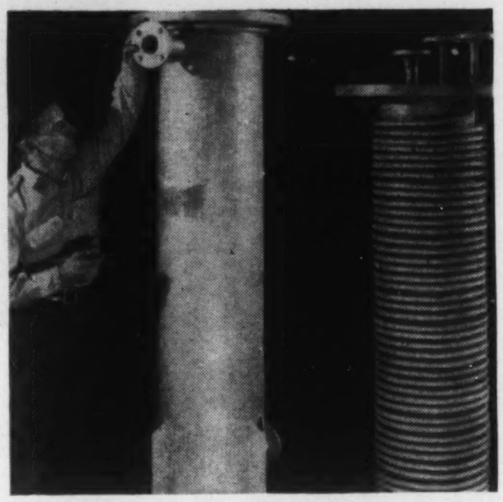
How Temperature Affects Ampco 8



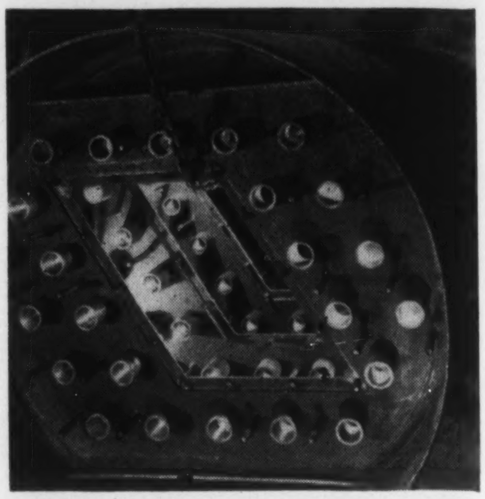
Cold finished **Annealed** **Arc welded**



Effect of temperature *on impact strength of Ampco 8.*



Fractionating tower *uses Ampco 8 alloy for a variety of parts.*



Heat exchanger *uses Ampco 8 alloy throughout.*

coupled with a corrosive solution or atmosphere and a high applied or residual stress, eventually causes a grain boundary crack.

In a single phase alloy of aluminum bronze, for example, the aluminum atoms tend to segregate at the grain boundaries during solidification. The corrosive oxidizes these atoms and their adjacent areas, and the high stress breaks the oxide film. The cycle is then repeated to eventual failure.

According to Klement, the addition of a small amount of tin prevents intergranular stress corrosion cracking because tin has a greater tendency than aluminum to segregate at the grain boundaries—and tin is not subject to corrosive attack by steam.

Uses and available forms

The new aluminum bronze alloy, called Ampco Grade 8, is available in the form of hot rolled and annealed sheet and plate; rod; wire coils up to 3/8 in. in dia; seamless pipe and tube in sizes from 1/4 in. to 4 in. o.d.; and finished products such as bolts, nuts, studs, rivets, and cold headed, thread rolled and screw machine parts.

According to Ampco, the new alloy is currently finding use for such things as heat exchangers, fractionating towers and high pressure piping in the petroleum, petrochemical, food, paper and chemical processing industries. Some specific examples of the material's use are shown in the accompanying photos.

Greater Precision in Rubber Moldings Now Possible

■ Greater precision and uniformity in molded rubber parts are now possible as a result of a new molding technique developed by Ohio Rubber Co., Div. of Eagle-Pitcher Co., Willoughby, Ohio. According to the company, the process is the first fully automated continuous process for molding of rubber parts, and as many as 200,000 parts per day can be molded on a single 48-in. machine.

In addition to high speed production, the new technique offers three primary advantages: 1) a degree of dimensional accuracy not economically obtainable by any other rubber forming method; 2) cost reductions; and 3) assured uniformity of parts.

The process is best suited to relatively small, functional parts which require a significant degree of dimensional accuracy and high quality of material. Parts presently being molded include seals for automotive shock absorbers and universal joints, washers, end caps for electric condensers, aerosol container valve parts, engine valve stem deflectors, fastener components, o-rings, grommets and gaskets. According to Ohio Rubber, any rubber material (synthetic as well as natural) with Durometer hardness ranging from 45 to 95 can be molded.

Dimensional accuracy

Accuracy equal to or better than that obtainable by any other rubber forming process is claimed for the new automatic molding method. In general, diameters can be held to within ±0.003-0.005 in., depending on size. A critical dimension on one part now in production is being held to within ±0.0025 in. On another part, with a thin section and relatively large diameter, surfaces are produced parallel to within ±0.003 in. Accuracy is substantially the same for fixed or closure dimensions because flash is said to be precisely controlled.

Approximate maximum part dimensions with full tooling are 1¼ in. in dia and 1-in. in thickness. Actual limits, however, depend on shape, total mass of the part and the type of material.

Production rate

Although production rate of each of the machines can be maintained at 200,000 parts per day, size of the part and type of material are limiting factors. In order to produce larger parts, for example, fewer than the maximum of 104 molds can be accommodated and production will decrease. Also, many low-grade compounds require a long curing time and the rate is therefore much slower.

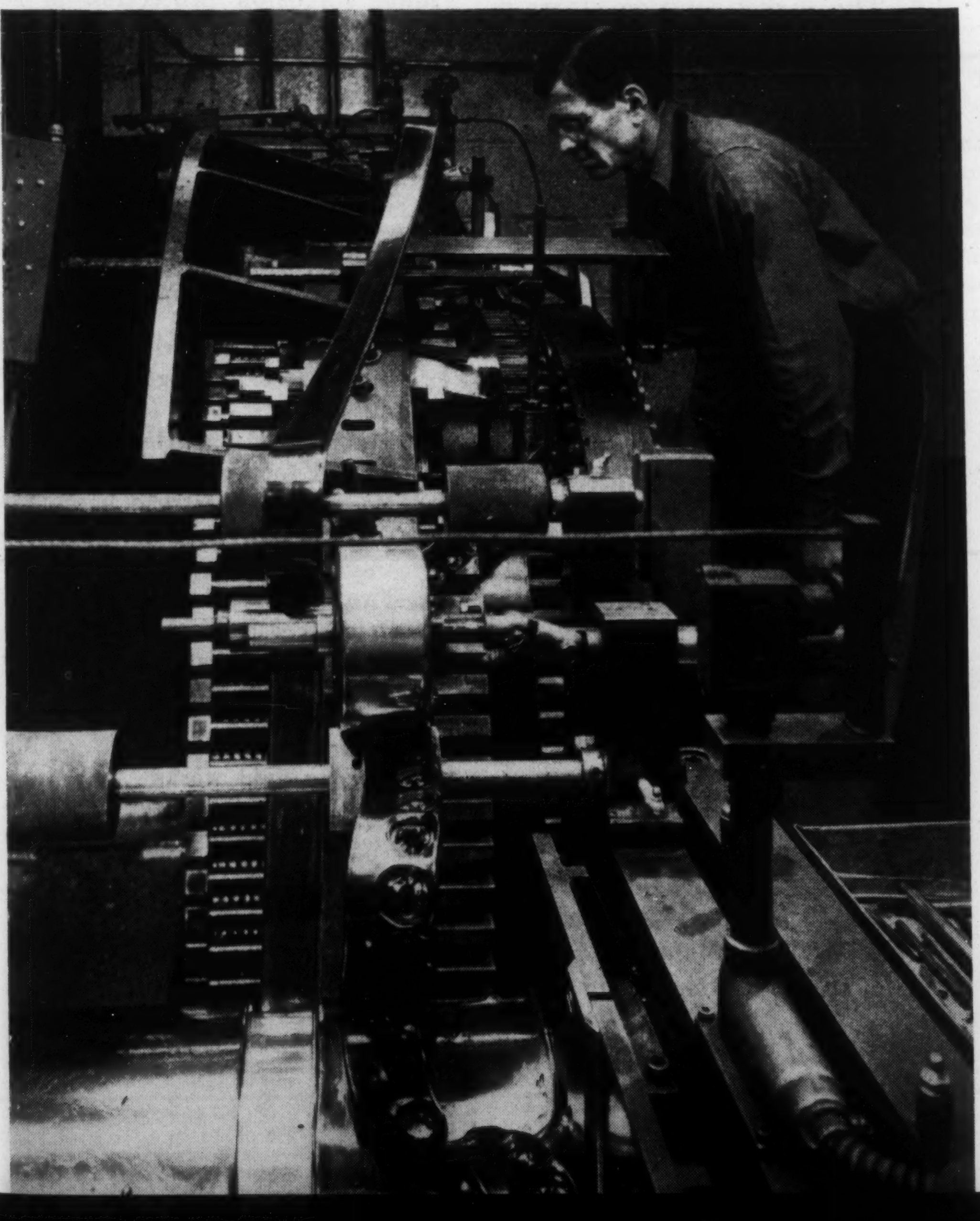
According to the company, the new method's one limitation is expensive tooling costs, and an annual production of a million parts will normally be required to justify tooling. There is a decided cost saving, however, on large volume production.

The process

Each rubber molding machine consists essentially of a two-roll plasticizing mill with integrated rotating molding equipment. The molding equipment consists of two vertical 48-in. wheels mounted on a common axle and spaced several inches apart (see photo below). The outboard wheel normally mounts the mold cavities, and the inboard wheel holds the force plugs (in this arrangement, the female mold cavities are fixed and the force plugs are movable). The force plugs are mounted on trunnions extending through the inboard wheel and are activated by spring loaded toggles. In effect, each unit is an individual mechanical press with a self-registering, single cavity mold. With full tooling there are 104 single cavity molds on each machine.

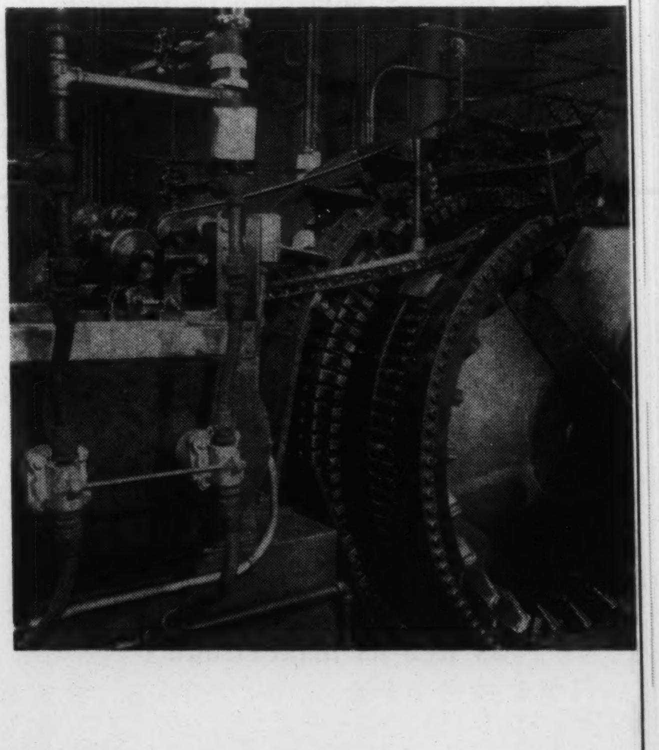
Each mold goes through a complete molding cycle during each revolution of the wheel. Opening, closing and "bumping" of the molds is controlled by stationary cams on which the follower of each mold toggle rides. Although the cam action can accurately control the timing of each of these operations in the cycle, molds are closed and held by toggle action against precisely adjusted springs in order to assure accurate control of pressure.

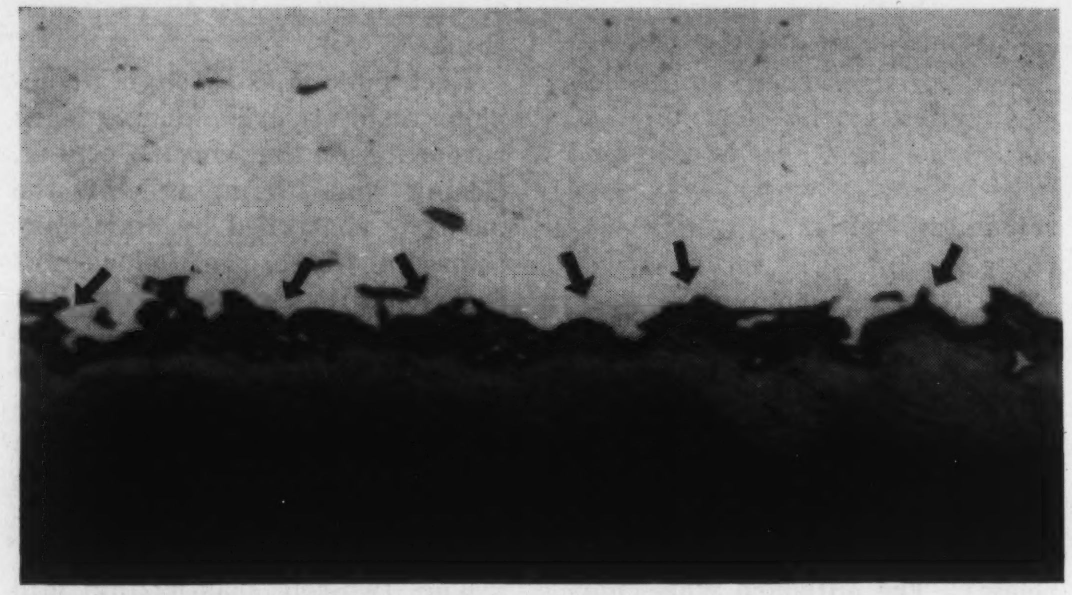
The two-roll plasticizing mill (see photo below) is periodically supplied by the operator with compounded stock; all other operations are continuous and automatic. Rotary knives cut from the mill a continuous ribbon of material which is fed over a closed loop of rollers to the open mold halves. Each mold cuts the exact amount of material it needs from the ribbon as it closes and the ribbon is then fed back to the mill.



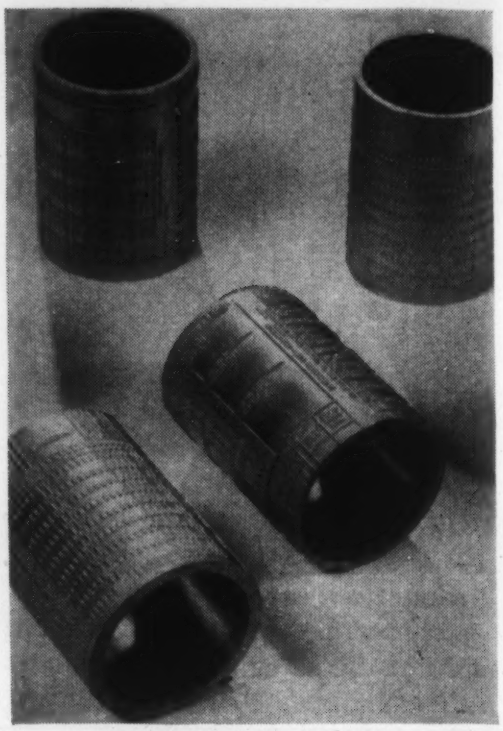
Plasticizing mill *feeds continuous ribbon of rubber compound to . . .*

. . . rotary molding equipment *where molds punch out required stock; the rubber compound then returns to the mill and is reworked into a smooth ribbon.*





Etch pits *(arrows), created during surface conditioning of magnesium, are filled with Dow's new electroless nickel plate (narrow gray band).*



Original detail *of magnesium printing cylinders is preserved after plating them with Dow's electroless nickel process.*

Electroless Nickel Gives Hard Surface to Magnesium

■ An electroless process for nickel plating on magnesium has been developed by Dow Chemical Co., Midland, Mich. Dow has not revealed the composition of the plating bath but does say it is ". . . a special nickel solution that eliminates the need for complex electrode equipment used in electroplating."

High hardness and uniform coating are two outstanding features of the plating process and this is said to make it advantageous for plating magnesium printing cylinders and plates. The electroless nickel process plates uniformly over both raised and low areas and does not build up on sharp corners, preserving the plate or cylinder's original detail.

In addition to plating printing rolls, the plating process can be used to plate magnesium electronic parts and the inside of magnesium tubes.

Advantages of process

1. The plating solution does not contain hydrochloric acid as other electroless nickel plating solutions do.

2. The process can be used to plate steel, aluminum and copper as well as magnesium.

3. The process does not require electric current.

4. The finish can be built up to any desired thickness like electrodeposited coatings.

5. The nickel solution starts a catalytic reaction on the surface of the metal and deposits a uniform finish which fills imperfections, swirls and narrow cracks in the metal. The finish is also said to uniformly cover the inside of drilled holes and other recesses.

6. The nickel finish contains 7 to 9% phosphorus and becomes an age hardening alloy having high hardness and good abrasion resistance.

7. Tin, chromium, zinc, silver, gold and cadmium may be plated over the nickel finish.

8. Acid core solders can be used to join an electroless nickel plated magnesium part. Dow recommends that nickel plated parts be tin plated first if rosin core solders are used.

How process works

The plating process starts by surface conditioning magnesium metal by degreasing, followed by chemical etching. After etching the metal is defilmed and immersed in the nickel plating solution for a prescribed period of time; each step is followed by a water rinse. Zinc immersion plus copper strike can be used with the new electroless process if maximum corrosion protection is required.

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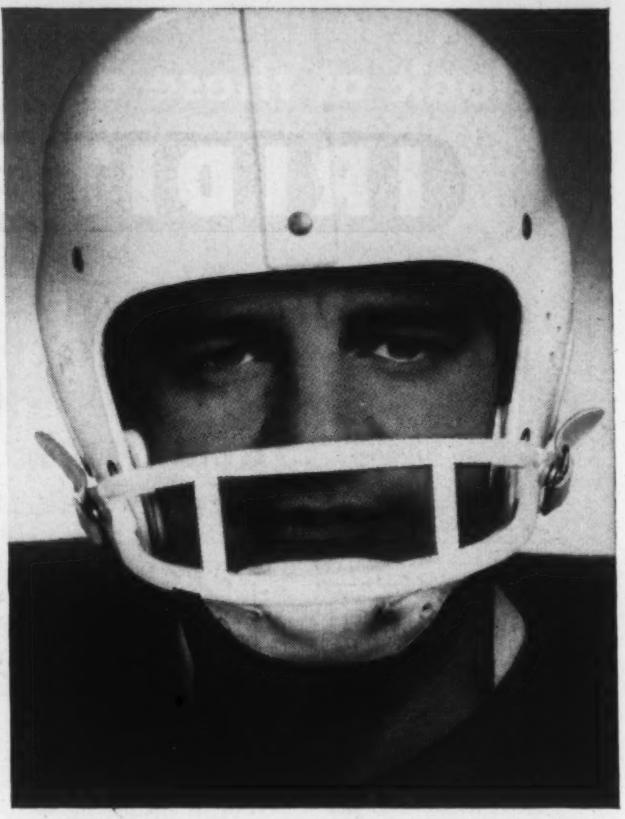
"See how much easier this flexible guard goes on!" John DePaulis (left) demonstrates to John Cowden the extra benefits of the Marietta football face guard, made from Spencer Nylon.



Better vision, too. Because Spencer Nylon is metal-tough as well as plastic-light, even thin guards give good protection.

More Flexible Nylon Solves Molding Problem

Special properties of Spencer Nylon give Texas product needed extra flexibility plus metal toughness . . .

A perplexing problem recently faced Dr. M. T. Marietta, a Texas dentist and manufacturer. Dr. Marietta had a molding problem requiring a material that was both flexible *and* tough. In addition, the material had to be lightweight and easy to mold. The solution he found may help you, too.

His problem began the day that Texas Christian University's star back, Lindy Berry, broke his nose and jaw in football practice. Soon after that, Berry appeared in the office of Dr. Marietta. Berry intended to play the season out, he declared, and he wanted a protective guard for his broken bones. For this emergency, Dr. Marietta produced a hand-made face mask. With it, Berry not only played out the season, but also made All-American. This was the beginning of what is now known as the Marietta Safety Mask Co., of Dallas.

Most face guards of the past were steel, dip-coated with rubber. They were impractical and often dangerous. Guards made of other plastics were so rigid that it was often hard to pull off the helmet without practically disjointing the player's ears. Then Dr. Marietta thought of nylon. He first tried an earlier-type nylon, but found the samples still too rigid.

The final answer turned out to be new, easy-to-mold Spencer Nylon. Dr. Marietta finds Spencer Nylon flexible, lightweight and durable under playing conditions. He reports less breakage with nylon than with any other materials. With Spencer Nylon, he can make guards that are slim, smooth and attractive.

Players can see better, too, through these slimmer guards. Also, because Spencer Nylon is easy to dye, schools can have these bars dyed in their own school colors. And the superior design of the guard makes it easy to install on the helmet.

The company started to make molds for Spencer Nylon face guards in November, 1957. The first guards came off in February. By the first of May, the firm was behind in their orders. General Manager John DePaulis believes the volume may amount to 100,000 the first year. In fact, such gear may soon become compulsory for all football teams.

Your special needs may also find an ideal answer in Spencer Nylon. For complete information write: Spencer Nylon, Spencer Chemical Co., 516 Dwight Bldg., K. C. 5, Mo.

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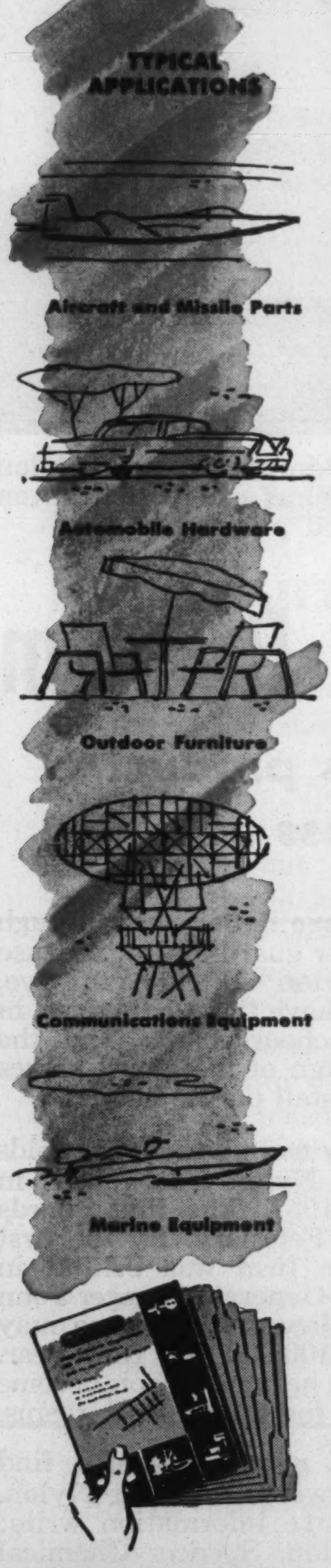

EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

OUTSTANDING PERFORMANCE—Forms a film that is an integral part of the metal itself. Can't flake, chip or peel. Takes paint firmly on initial application, and the bond lasts. Even protects areas scratched in use.

LOWEST COST—You have only minimum equipment cost, no special racks, high speed operation, lower overall handling costs.

CHOICE OF APPEARANCE—Clear coatings that retain metallic lustre to dark, maximum protection coatings. A variety of colors is available by dyeing.

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Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection.
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE #15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

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What's new IN MATERIALS

How Radiation Affects Plastics and Rubber

by N. M. Lazar and J. E. Ayer

Plastics and rubber with a benzene ring in their chemical structure have good resistance to radiation. For this reason such materials as polystyrene, filled furan, phenolic resins and glass fabrics laminated with aromatic thermosetting resins have a useful life of 1000 to 10,000 hr in a gamma flux of 10^6 r per hr.

Our findings were gleaned from an extensive literature survey on radiation damage to elastomers and plastics. We made the study mainly to facilitate the screening of certain polymers rather than to evaluate the relative damage done to materials that are exposed to radiation. The findings are summarized below:

Semi-organic, filled structures—Mica and glass tapes impregnated with silicone (essentially an inorganic structure) are virtually unaffected after exposure to radiation levels of 10^{12} r. Natural and filled furan plastics and mineral-filled phenolics show little change except for darkening in color when exposed to radiation of 6 x 10^9 r. Mineral-filled polyesters show a 50% decrease in impact and tensile strength at 6 x 10^9 r, whereas unfilled polyesters fail at 3 x 10^9 r.

Polystrenes—Polystyrene plastics and elastomers appear to be quite resistant at radiation levels of 10^8 to 10^9 r.

Laminates—Glass fabrics laminated with thermosetting resins suffer no decrease in mechanical strength and show no deterioration in electrical properties after being exposed to integrated dosages of 10^9 r in a flux field of 10^7 r per hr.

Acrylic rubbers and PVC — Acrylic rubbers and vinyl chloride materials are second in radiation

---

The authors are associated with Argonne National Laboratory.

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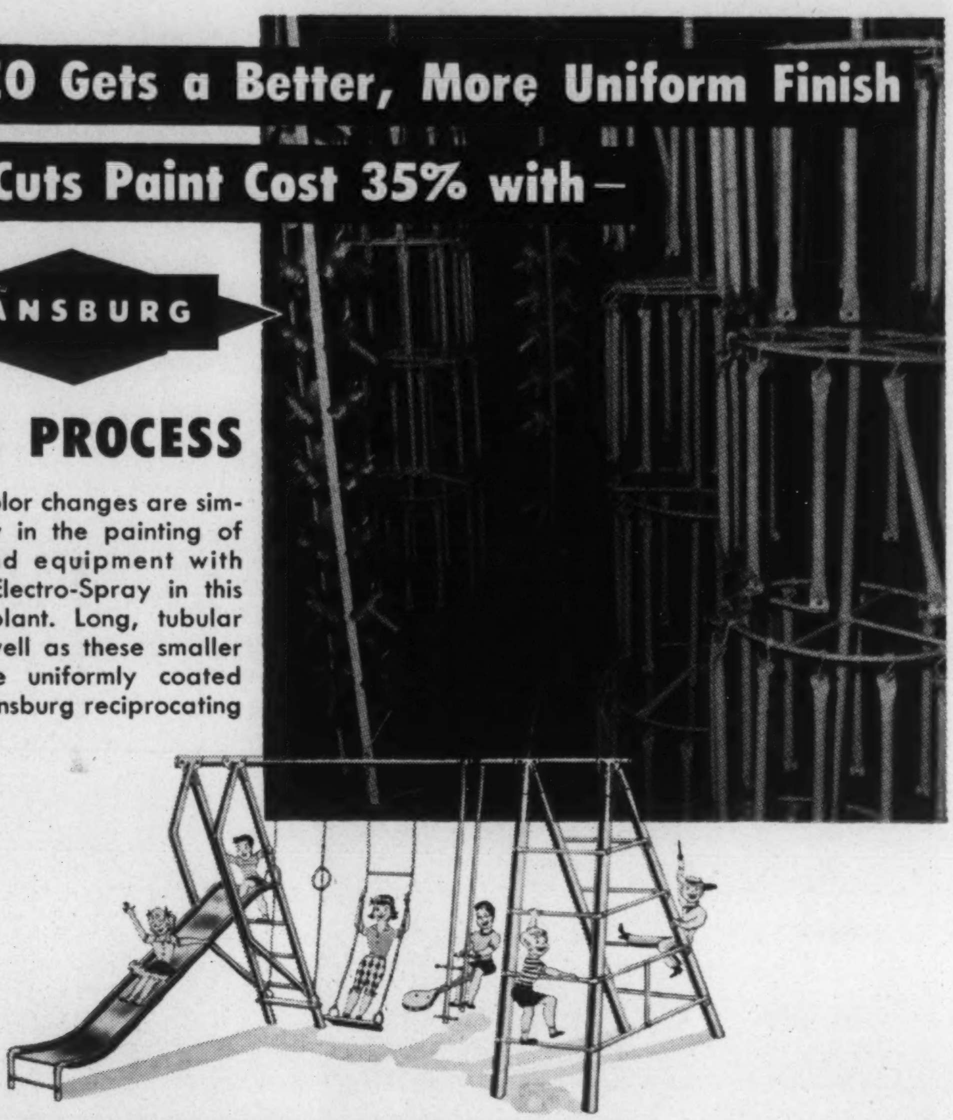

Frequent color changes are simplified now in the painting of playground equipment with Ransburg Electro-Spray in this St. Louis plant. Long, tubular parts, as well as these smaller pieces, are uniformly coated with the Ransburg reciprocating disk.

QUALITY IMPROVEMENT! That was Turco Manufacturing's chief reason for changing from flo-coat to electrostatic spray painting of their quality line of playground equipment.

Not only is Ransburg No. 2 Process providing a higher quality, uniform coating on all parts, but Turco is saving 35% in paint cost!

Simplicity in color change with Electro-Spray is another important advantage here. With Turco's production methods, colors are changed 15 times in an 8-hour shift. Now, changes are made on the fly with no down-time. By contrast, the former "stop and go" method would mean over an hour's lost time in a day's operation.

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resistance to polystyrene materials. Natural rubber is hardened, whereas butyl rubber is softened by irradiation.

Polyethylene — Polyethylene - type elastomers fail at about 10^7 r. Polyethylene and nylon in-increase in tensile strength and decrease in impact strength at exposures of 6×10^9 r.

Silicone—Silicone polymers are unstable above radiation dosages of 10^7 to 10^8 r and not dependable in usage beyond 10^7 r accumulated radiation.

Fluorocarbons—Teflon and Kel-F elastomers seem to have the poorest radiation resistance of all materials tested. These compounds become useless after accumulated exposure of 3×10^6 r.

Literature survey

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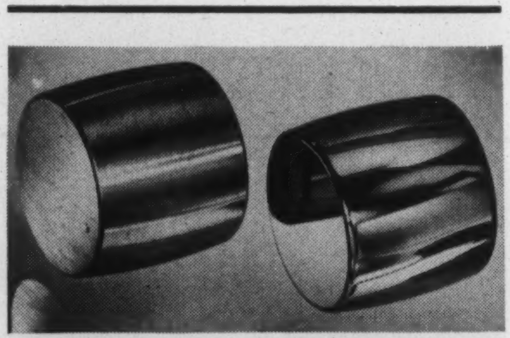

Barrel finished steel bearings—The high alloy steel bearing shown at left develops the bright, lustrous finish shown at right after being barrel finished for 10 hr in a new finishing machine developed by Roto-Finish Co., Kalamazoo, Mich. The finishing process, known as Cor-A-Brite, polishes parts in a single operation.

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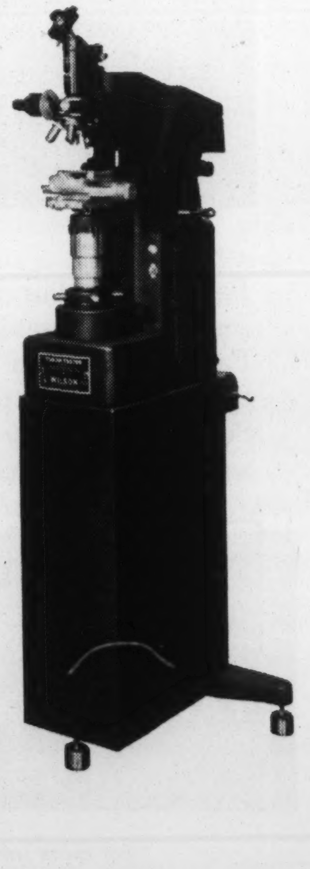
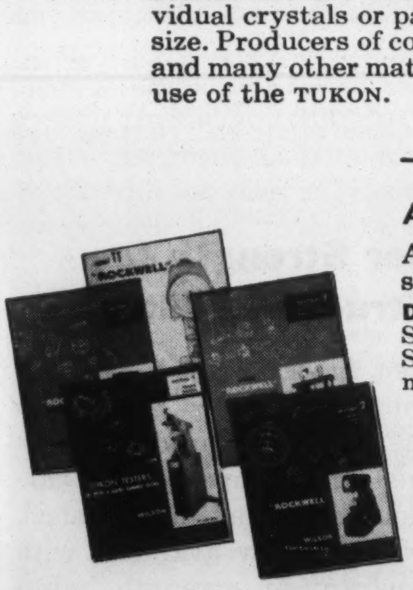
Three models are available to meet your individual requirements. TUKON Testers use both the Knoop and 136° Diamond Pyramid Indenter. Each TUKON Tester is a self-contained hardness testing instrument— no accessory equipment is needed. Knife edges and levers of fixed length are used throughout for application of exact load and freedom from internal friction.





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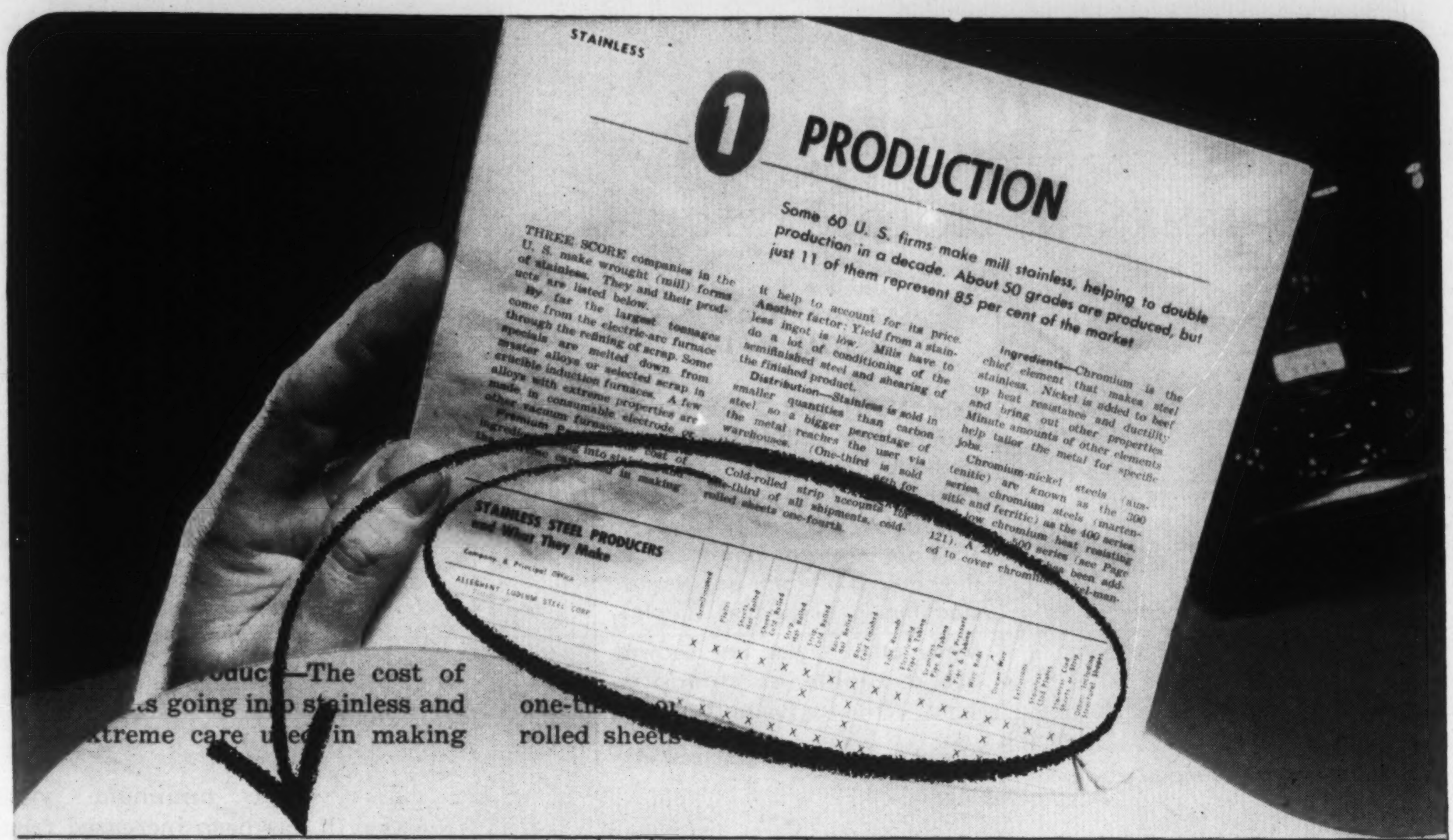
Higher Strength for Constructional Steel

United States Steel Corp., 525 William Penn Place, Pittsburgh 30, Pa. has announced that its quenched and tempered low carbon constructional alloy steel, called T-1, is now available with new guaranteed strength mini-

Experience—the __added__ alloy in **A-L Stainless, Electrical and Tool Steels**



STAINLESS

1 PRODUCTION

Some 60 U. S. firms make mill stainless, helping to double production in a decade. About 50 grades are produced, but just 11 of them represent 85 per cent of the market

STAINLESS STEEL PRODUCERS and What They Make Company & Principal Office	Semifinished	Plates	Sheets, Hot Rolled	Sheets, Cold Rolled	Strip, Hot Rolled	Strip, Cold Rolled	Bars, Hot Rolled	Bars, Cold Finished	Tube Rounds	Electricweld Pipe & Tubing	Seamless Pipe & Tubing	Mech. & Pressure Pipe & Tubing	Wire Rods	Drawn Wire	Extrusions	Stainless Clad Plates	Stainless Clad Sheets or Strip	Other, Including Structural Shapes
ALLEGHENY LUDLUM STEEL CORP. Pittsburgh	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
						X		X						X				

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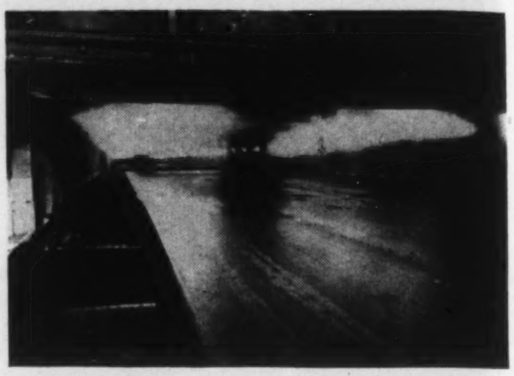


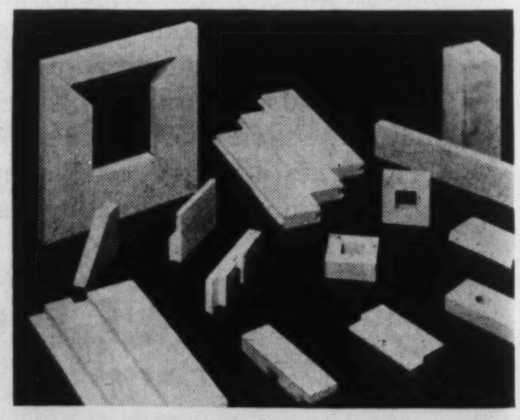
***Tempering** red hot T-1 steel at U. S. Steel's Homestead District Works. The higher physical properties inherent in the steel are developed in the course of routine production.*

mums. The minimum yield strength has been increased from 90,000 to 100,000 psi; the minimum tensile strength has been increased from 105,000 to 115,000 psi. The published tensile strength maximum of 135,000 psi remains unchanged.

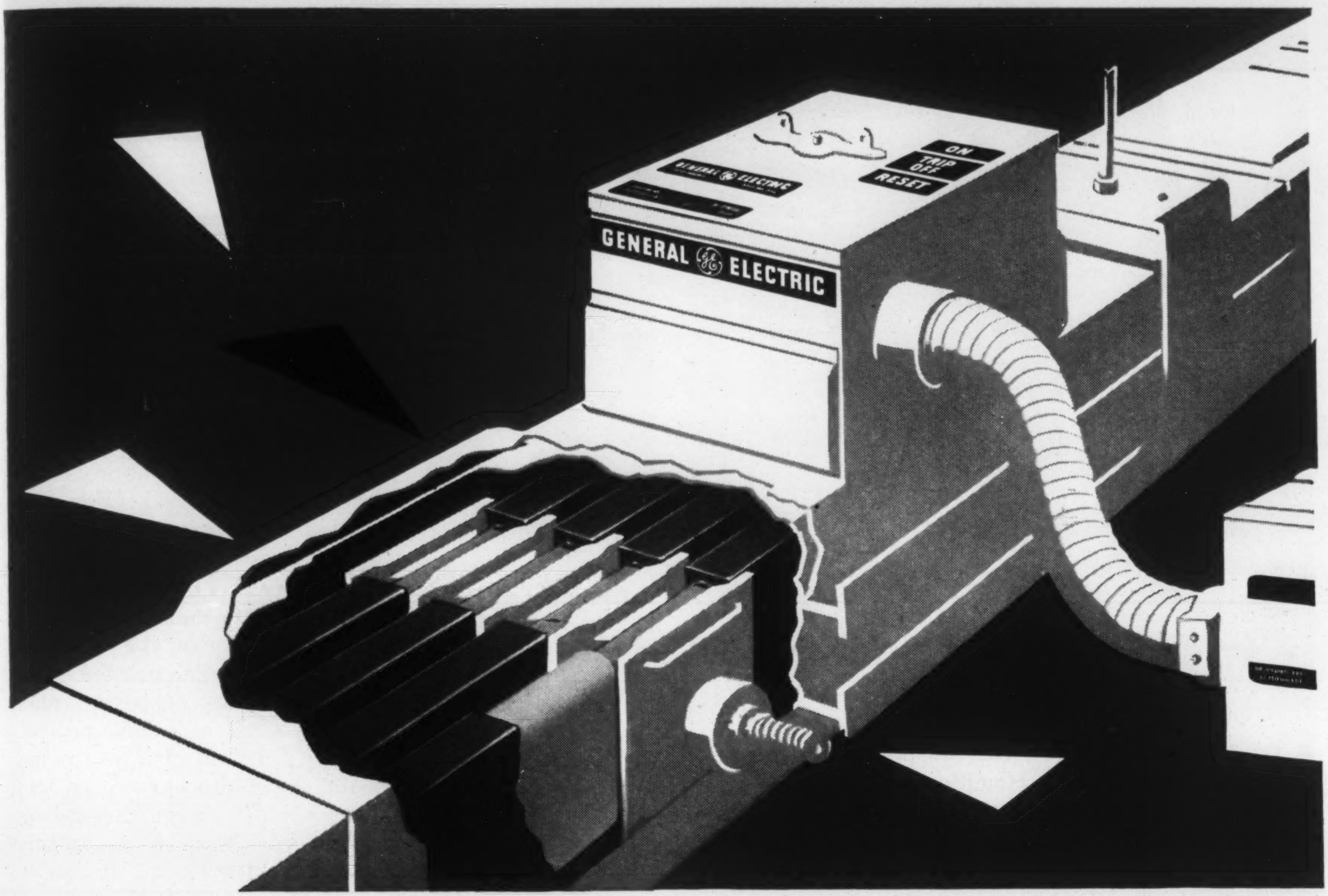
Wood Particle Board Is Dimensionally Stable

A new wood particle board that is said to have exceptional dimensional stability, low thickness swell, extremely smooth surface, and a non-splintering edge has been developed by National Starch Products, Inc., 270 Madison Ave., New York 16.

According to the producer, the product, called Extra Fine Granite Board, represents a refinement in particle size over that formerly



***Typical shapes** that can be made from wood particle board.*



When Enjay Butyl is used as continuous insulation of tubular aluminum conductors, traveling arcs are virtually eliminated, plug outlets are essentially dead-front.

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helps keep costs low in new Aluminum Busway!

Enjay Butyl is extruded over the full length of the conductors used in General Electric's new Type DE Busway, the first busway designed specifically for aluminum. This new busway incorporates all 22 features that engineers consider important in busway design, yet it is up to 30% smaller and 50% lighter than other busways of comparable rating.

Enjay Butyl rubber is ideal for use as continuous insulation of tubular conductors because of its inherent resistance to ozone and to heat aging. Add Butyl's excellent electrical properties, its vulcanizability and the fact that it is the *lowest cost* rubber on the market—and you'll understand why it was chosen above all other rubbers to do this job.

Every day manufacturers are discovering new ways to use economical Butyl. Find out how Enjay Butyl rubber can cut production costs for you. For further information and expert technical assistance, contact the Enjay Company.

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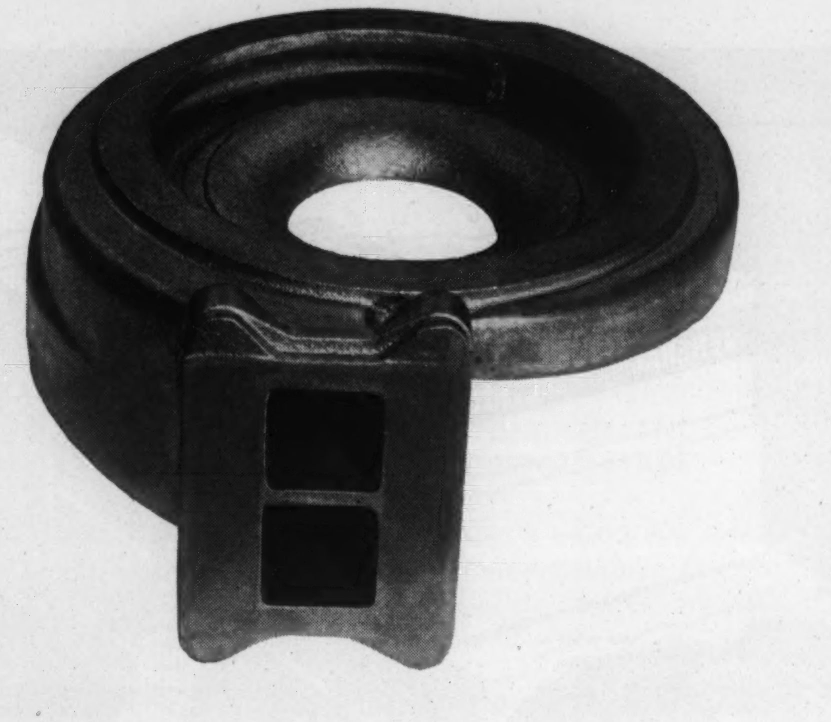

THERMAL SHOCK

A CASE IN POINT—This 20 pound Ni-Resist casting made for the Schwitzer Corporation by Hamilton Foundry is the turbine casing of a diesel engine turbocharger. Exhaust gases which turn the impeller at speeds up to 90,000 rpm subject the housing to rapid cyclic temperature changes up to 1500° F. Any free scale formed at these temperatures could erode and eventually destroy the impeller blades. Ni-Resist was chosen for this part because it produces practically no free scale, it resists growth and oxidation at high temperatures, and it resists cracking under thermal shock.

Ni-Resist iron combines three particular product engineering and design advantages. It resists oxidation: as low as .002 inches per year oxide penetration at 1400° F. Scale formed adheres to the base metal and reduces further oxidation to a minimum. It has high temperature strength: up to 12,000 psi at 1500° F. And it's the toughest of all flake graphite irons: Charpy impact strengths (unnotched) up to 150 ft.-lbs. Hamilton Foundry casts all types of Ni-Resist including Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

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used in the manufacture of the board. The particle board is manufactured by a closely controlled process in which wood particles are precision-sized to predetermined specifications. It is a homogenous blend of 100% virgin New England white pine plus a resin binder. Its density and handling properties closely approximate those of natural wood. (For comparative information on other wood composition boards, see M/DE, Aug '57, p 107.)

Fabricating the board

The board can be painted, colored, stained, printed and sprayed with a transparent plastics coating on a volume production basis. It can also be turned, ground, bent and curved, as well as laminated in large thicknesses to produce draw dies, pattern stock and thick blocks. It can be molded like many plastics.

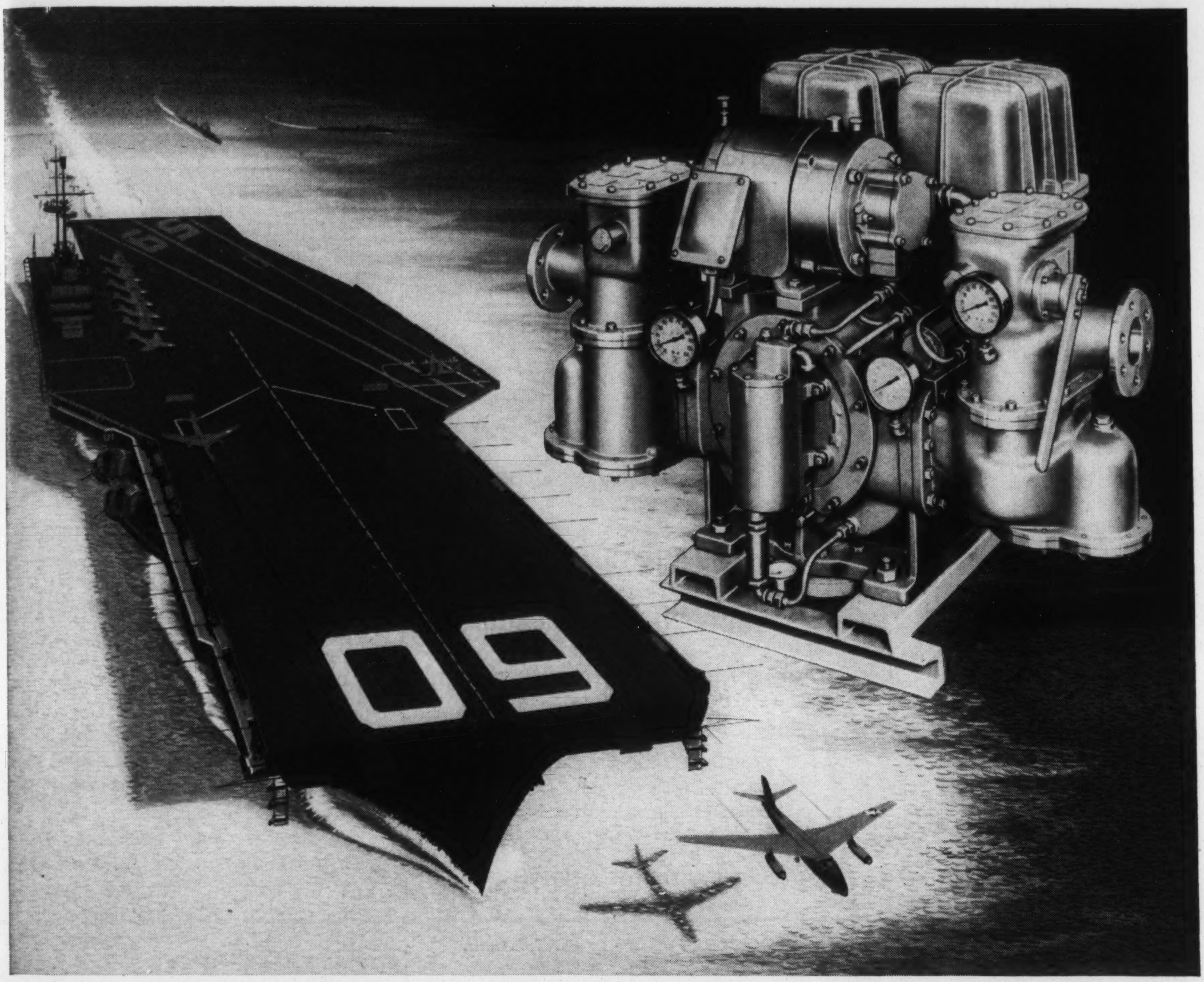
When faced with aluminum sheet. Granite Board is said to have good insulating properties with the added advantage that it can be worked with woodworking rather than with metalworking tools. Its acoustical value is reported to be above that of wood.

The wood product is currently marketed in states east of the Mississippi River and north of North Carolina.

Acrylic Rubber Best for Hot Hydraulic Fluids

Acrylic rubbers seem to offer the best resistance to silicate ester hydraulic fluids operating at 400 F, recent research shows. Acrylic polymers did not crack after oil aging for 500 hr at 400 F, whereas other polymers crack after 200 hr aging.

The hydraulic system of supersonic aircraft requires numerous rubber packings and hose; these rubber parts must withstand prolonged high heat and the corrosive action of hydraulic fluids. Silicate ester fluids seem to be the



How Kanigen® coating helps eliminate rust from jet fuel systems

Fuel systems engineers faced a major problem in corrosion when jet aircraft went to sea. Aircraft carrier systems for fueling planes are aqua-systems—which means that to prevent accumulation of explosive vapors in half-empty tanks, water replaces fuel as it is pumped out of the carrier storage tanks. Blackmer fueling units, made by Blackmer Pump Company in Grand Rapids, Michigan, frequently are used.

High test aviation gasoline does not absorb moisture. Jet fuel does. This moisture, with high salt content, reaching unprotected steel castings, created rust which contaminated the fuel and caused malfunctioning.

Blackmer pumping units, made from steel castings to meet high shock requirements, were protected with KANIGEN® nickel-alloy coating. They were used and evaluated at sea for two years.

The KANIGEN coating was found superior because (1) it gave better initial overall coverage, and (2) the KANIGEN coating did not chip or break away from machine surfaces as some other coatings do.

If you have a corrosion problem, consult our engineers. You'll find *. . . it pays to plan with General American.*

KANIGEN®

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United States Gasket *Plastics Division of* **GARLOCK**

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best to use at high temperatures, but these fluids are hard on rubber parts, usually swelling them out of shape or cracking them. This problem was the subject of an intensive research program conducted by L. E. Novy and R. A. Clark of Battelle Memorial Institute. Details of their work are presented in the May and June '57 issues of *Rubber Age*.

Many elastomers studied

In addition to acrylic rubbers, the two researchers investigated neoprene (CR), nitrile (NBR), vinyl pyridine, and butyl (IIR) rubbers, including the effects of different fillers, accelerators and plasticizers. Desired physical properties before and after aging are shown in an accompanying table. The results of Novy and Clark's work are summarized below:

Neoprene compounds when aged at 400 F in the test fluid survive 72 hr without cracking, but at the end of 168 hr they crack when bent at 180 deg. Improved resistance to cracking was found in compounds containing high amounts of zinc oxide; for instance, these compounds did not crack when flexed after aging for 168 hr in the fluid, whereas many of the other samples cracked after aging for only 72 hr.

In a series of tests to judge the relative merits of magnesia as a filler, Novy and Clark found that cracking is more likely to occur in neoprene compounds high in magnesia and low in zinc oxide rather than in those that are high in zinc oxide and either high or low in magnesia.

The two investigators found that rubberlike properties in neoprene compounds could be maintained for at least 168 hr at 400 F by judicious choice of fillers and curatives. Though such compounds usually have lower tensile strengths than the more conventional, black-filled compounds, they are superior in their ability to retain rubberlike properties after

For handling
FRICTION
CORROSIVES
HIGH and LOW
TEMPERATURES

X-RAY photos show typical uses of Du Pont TFE resins . . . seals in chemical valve and bearings in gear pump.

Here's why seals and bearings of TFE-fluorocarbon resins may be your solution

TFE-fluorocarbon resins have the lowest coefficient of static friction of any solid substance known. Under high loads, coefficients lower than 0.016 have been measured. The resins have practically universal chemical inertness and are rated for continuous use at temperatures from −450° to 500°F.

TFE BEARINGS can operate dry in assemblies where lubrication is difficult or impossible. *As in the pump shown above, which handles hydrogen peroxide, ethylene oxide, hydrazine, they* perform unharmed and keep products free of contamination by lubricants. TFE bearings can be tailored for high loads, high velocities or high wear resistance by the use of reinforced constructions.

TFE SEALS are not damaged by vicious chemicals or temperature extremes. *As in the valve shown above,* their low surface friction makes for low torque, easy operation, perfect release from metallic contact. TFE fluorocarbon seals are available in all basic designs and configurations.

DISCOVER how you can improve your products and processes with seals and bearings of Du Pont TFE-*fluorocarbon* resins. For product *and design* information see your local supplier. Look *for him* under "Plastics—Du Pont" in the Yellow Pages or write to: **E. I. du Pont de Nemours & Co. (Inc.), Room ME-2524, Nemours Building, Wilmington 98, Delaware.** In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

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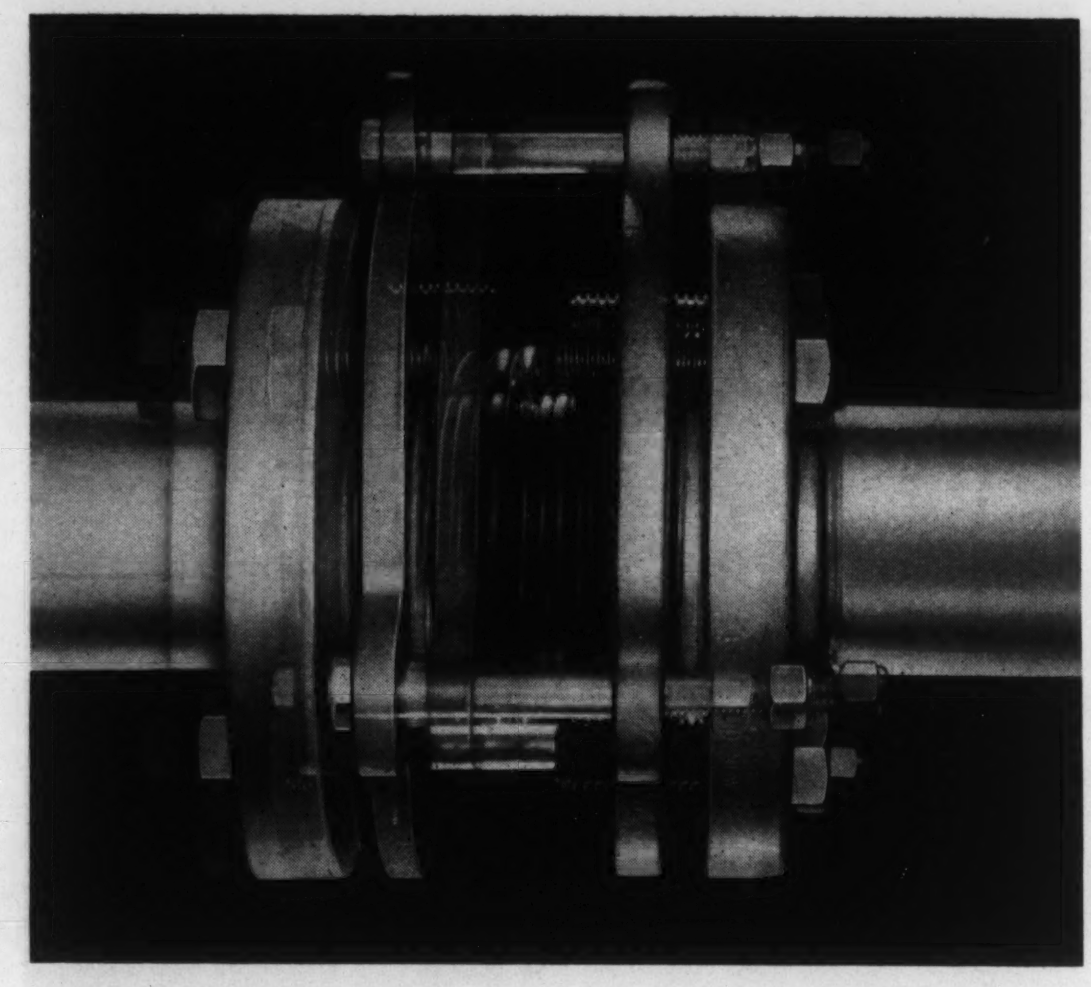
TFE-FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

For more information, turn to Reader Service card, circle No. 361



Fluoroflex®-T expansion joints molded from Teflon® stand higher dynamic pressure

Wide pressure range—full vacuum, too

Unequalled flex life—through special Teflon compound

Molded—not machined—for undamaged grain structure and interior convolutions that don't fatigue and crack

Corrosion-proof—universally useful with all fluids, all piping

Fluoroflex-T bellows and flex joints are made of a special high density compound . . . Teflon at its best. Molding assures the optimum tensile and fatigue strength.

RESULT: *Twice the burst strength,* after flexing . . . 20 to 30 times the flex life of ordinary bellows machined from Teflon!

Chemically as well as physically durable, Fluoroflex-T bellows are inert to virtually all known chemical and corrosive solutions.

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® Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
® Teflon is DuPont's trademark for TFE fluorocarbon resins.

RESISTOFLEX

For more information, turn to Reader Service Card, circle No. 471

HOW RUBBER SHOULD PERFORM IN SILICATE ESTER FLUIDS

ORIGINAL PHYSICAL PROPERTIES	
Min Tensile Strength, psi	1500
Min Elongation, %	200
Durometer Hardness	A 60 to 80
Low Temp Flexibility, F	−65
PROPERTIES AFTER IMMERSION[a]	
Min Tensile Strength, psi	800
Min Elongation, %	100
Durometer Hardness	A 60 to 85
Low Temp Flexibility, F	−65
Volume Change, %	+5 to +30

[a] Aged 500 hr at 400 F.

prolonged aging.

Nitrile compounds were evaluated because of the well known oil resistance of this class of rubbers. However, the researchers found that this type of rubber loses an excessive amount of elongation and is prone to cracking. In addition, the low temperature properties of nitrile compounds (−55 F) are not good enough to permit use of nitrile rubber parts in military aircraft hydraulic systems. A carboxylic-modified nitrile rubber was evaluated and found to harden excessively after aging.

Vinyl pyridine compounds easily meet the original tensile strength requirement of 1500 psi, but after aging their tensile strengths drop below the 800 psi minimum to about 500 to 600 psi. In general, all vinyl pyridine stocks are low in physical properties and have poor crack resistance.

Acrylic compounds are in a class by themselves for maintaining elongation after aging; after 500 hr they have an elongation of 400 to 500%. In crack resistance, acrylic rubber compounds are vastly superior to other rubber com-

PROPERTIES of most engineering materials can be found in M/DE's *Materials Selector* reference issue, published last September. Names and addresses of suppliers are also listed.

For more information, circle No. 364 ➤

DESIGN ENGINEERING DATA*

A New, LOWER COST – High Efficiency Fluorocarbon

RULON®

- newest, *most versatile* "SUPER TEFLON".
- *Lowest priced* of all comparable fluorocarbons.
- a modified TEFLON fluorocarbon enhanced by a superior blend of additives and reinforcing agents.
- an *accepted, tested* and *proven* TEFLON offspring with broader, more efficient and more economical applications.
- a dynamic Design and Engineering material: super performance with *improved* properties.

ESTED RULON PROPERTIES:

(as compared to TEFLON†)

■ SUPERIOR:

- Wear Resistance
- Hardness
- Stiffness
- Cold Flow
- Deformation Under Load
- Compressive Strength
- Thermal Conductivity

■ SIMILAR:

- Elongation
- Impact Strength
- Tensile Strength
- Electrical Insulation

■ SAME:

- Low Coefficient of Friction
- Extreme Heat Resistance
- Chemical Corrosion Resistance
- Non-flammability
- Outdoor Durability
- Zero Water Absorption
- Flexural Strength
- Non-stick Properties

†DuPont's TFE Fluorocarbon Resin

(Write for actual values)

PROVEN RULON APPLICATIONS

ELECTRICAL

Relays, Potentiometers, Antennae, Terminals and Connectors, Bushings and Washers.

CHEMICAL

Bearings for Acids and Dyes; Non-toxic Bearings for Food and Liquid Processing; Oil-free Bearings; Freon-resistant Seals; Refrigeration Seals.

MECHANICAL

Piston Rings, Torque Control Bushings, Textile Bearings, Rotary Seals, Cam Followers, Pump Bearings, Cups and Seals, Thrust Washers, Gaskets and Packings, Valve Seats.

(Write for actual applications)

RULON®

a "super-TEFLON" whose properties and lower cost create applications never before possible for a designed-in and engineered material. *RULON* is the answer to a low-cost replacement for sintered metals, ball bearings, wood, glass, ceramics and expensive fluorocarbons. Select RULON *for more and longer performance at a lower cost.*

Write for further information and prices.

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Precision Resistance,
Chemical and
Mechanical Alloys—

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pounds; no cracking was noted with this type of rubber after oil aging for 500 hr at 400 F.

Other rubber compounds, such as butyl and Kel-F elastomer, show no promise for this application. Butyl rubber compounds disintegrated during aging; Kel-F elastomer compounds have extremely low tensile strength after aging.

Ten New Epoxies for Electrical Uses

A total of ten new epoxy resins have recently been introduced for use in electrical and electronic devices.

Minnesota Mining's resins

Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn., has added three new high temperature epoxy resins to its "Scotchcast" line of resins. The resins were developed specifically for electrical and electronic parts that operate continuously at temperatures as high as 400 F.

No. 250 is a two-part, rigid, unfilled resin suitable for impregnation and embedment. It has a viscosity of 10 cps at 200 F, a cure time of 2 hr at 250 F, and a pot life of 3 to 4 days.

No. 251 is a filled version of No. 250 and is recommended for casting, impregnating and encapsulating applications where structural strength is desired.

No. 252 has physical and electrical properties similar to the other resins, but is formulated specifically for dipping applications.

All three resins have a weight loss of 3.5% after 1000 hr at 430 F; a dielectric strength of 525 v per mil; an arc resistance of 77 sec; and a water absorption of 0.25% after 240 hr immersion at room temperature.

Minneapolis-Honeywell's resins

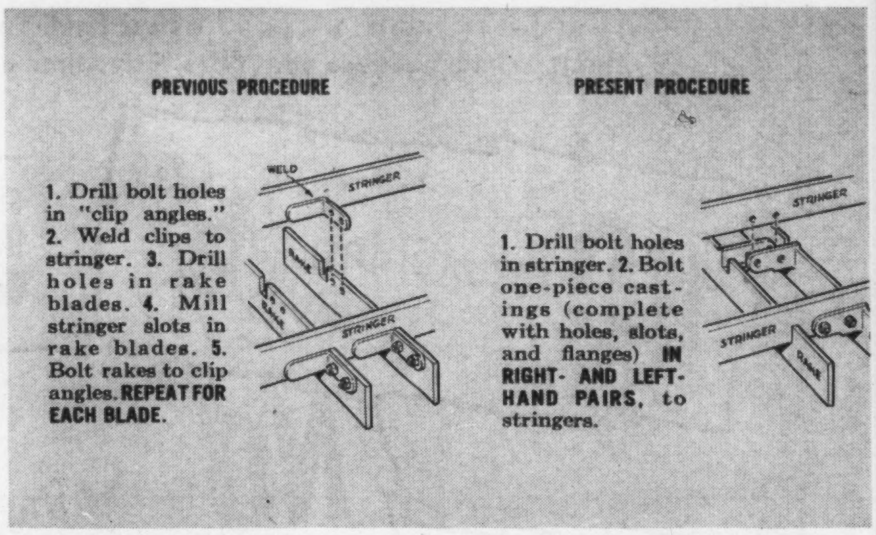
Minneapolis-Honeywell Regulator Co., Plastic Products Dept.,

How to cut costs, improve product design with stainless steel close-tolerance castings

Cooper Alloy design collaboration with advanced casting techniques can simplify your fabrication, cut your costs. Here's how:

Casting of intricate parts: Jet engine afterburner component, cast for Pratt & Whitney Aircraft by Cooper Alloy, is a tangle of projections and cavities. Required, however, were the most precise dimensions to make for automatic precision machining. Shellcast® shell coring and CO_2 process cut down rejection and machining costs.

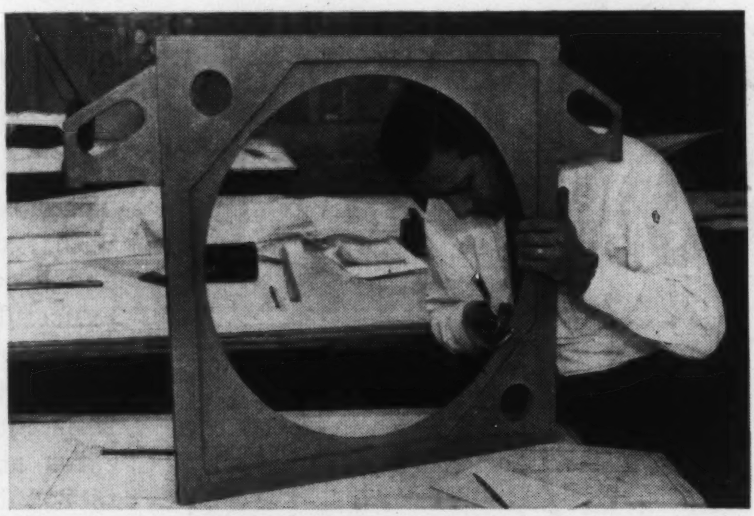
Strength and quality: Castings stronger than forgings! These Cooper Alloy nuclear service fittings possess high-temperature yield strengths 20% higher than minimum code specifications. Tough quality requirements have been met and bettered on a regular repetitive quality basis.



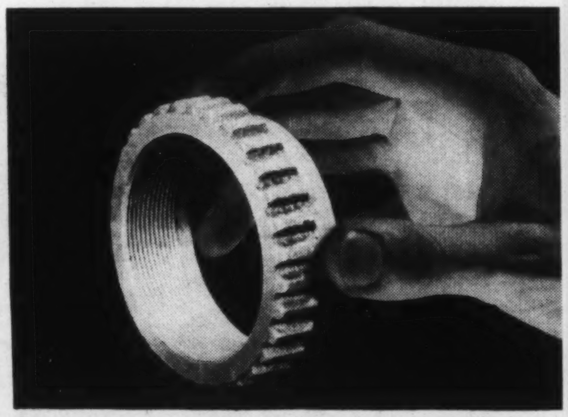
1. Drill bolt holes in "clip angles." 2. Weld clips to stringer. 3. Drill holes in rake blades. 4. Mill stringer slots in rake blades. 5. Bolt rakes to clip angles. **REPEAT FOR EACH BLADE.**

1. Drill bolt holes in stringer. 2. Bolt one-piece castings (complete with holes, slots, and flanges) **IN RIGHT- AND LEFT-HAND PAIRS,** to stringers.

Part redesigned, simplified, assembly costs lowered. Classifier rake blade, Shellcast® by Cooper Alloy for Dorr-Oliver Inc., was originally made by welding cast and machined elements. Close-tolerance, smooth-surface shell castings made possible design change to one-piece cast unit, eliminating welding and much of the assembly costs.



Casting of thin-walled close-dimensioned parts. Tennessee Eastman filter frame plate previously required a good deal of careful milling on thin inner web. Combined use of shell core in a sand mold held tolerances, eliminated milling operation.



Product improvement: Gear lugs on adjusting ring for Manning, Maxwell & Moore pressure safety relief valve, formerly sand cast, are now being produced directly by Shellcast® process. Dimensional accuracy possible with shell castings permitted redesign of part to give more lugs, finer adjustability in use.

If you haven't looked over your fabrication and assembly costs lately, check the unusual cost-saving techniques listed in the capsule stories shown above. They are typical of Cooper Alloy advanced casting know-how. Many parts and assemblies that you probably haven't even considered as makable by castings, can be now by Cooper Alloy, specialists for over 35 years in casting *only* stainless steel.

Want more information? To learn more of how Cooper Alloy know-how can help cut *your* manufacturing costs, write for our free 16-page booklet, "Cooper Alloy—Pioneering in Stainless Steel." Also available, information on the other problem-solving Cooper Alloy products listed below.

COOPER ALLOY

Corporation • Hillside, New Jersey

SPECIALISTS *in Stainless Steel valves, fittings, castings; Plastic pumps, pipe, valves, fittings*

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Our Laminum Shims are good news for thousands of metal working plants, because our "NOs" save time and reduce costs.

—get the full story at the Design Show Booth No. 939

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LAMINATED SHIMS OF

LAMINUM®

SURFACE BONDED . . . THEY peel FOR ADJUSTMENT

And only in Laminum are laminated, surface-bonded shims available *in all four materials* as shown below.

Laminated Shims of LAMINUM now available in

STAINLESS STEEL with laminations of .002" or .003"	LOW CARBON STEEL with laminations of .002" or .003"
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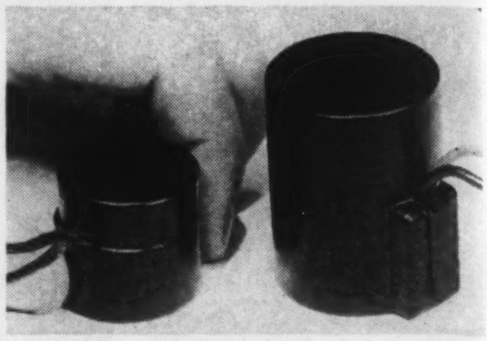


Epoxy coils *made of 3M's Scotchcast brand resins are capable of continuous operation at 400 F.*

2753 Fourth Ave. S., Minneapolis 8, Minn., a newcomer in the plastics field, (see M/DE, Oct '57, p 276), has introduced seven new epoxy casting, potting and foaming resins under the trade names of "Sealcast" and "Sealfoam."

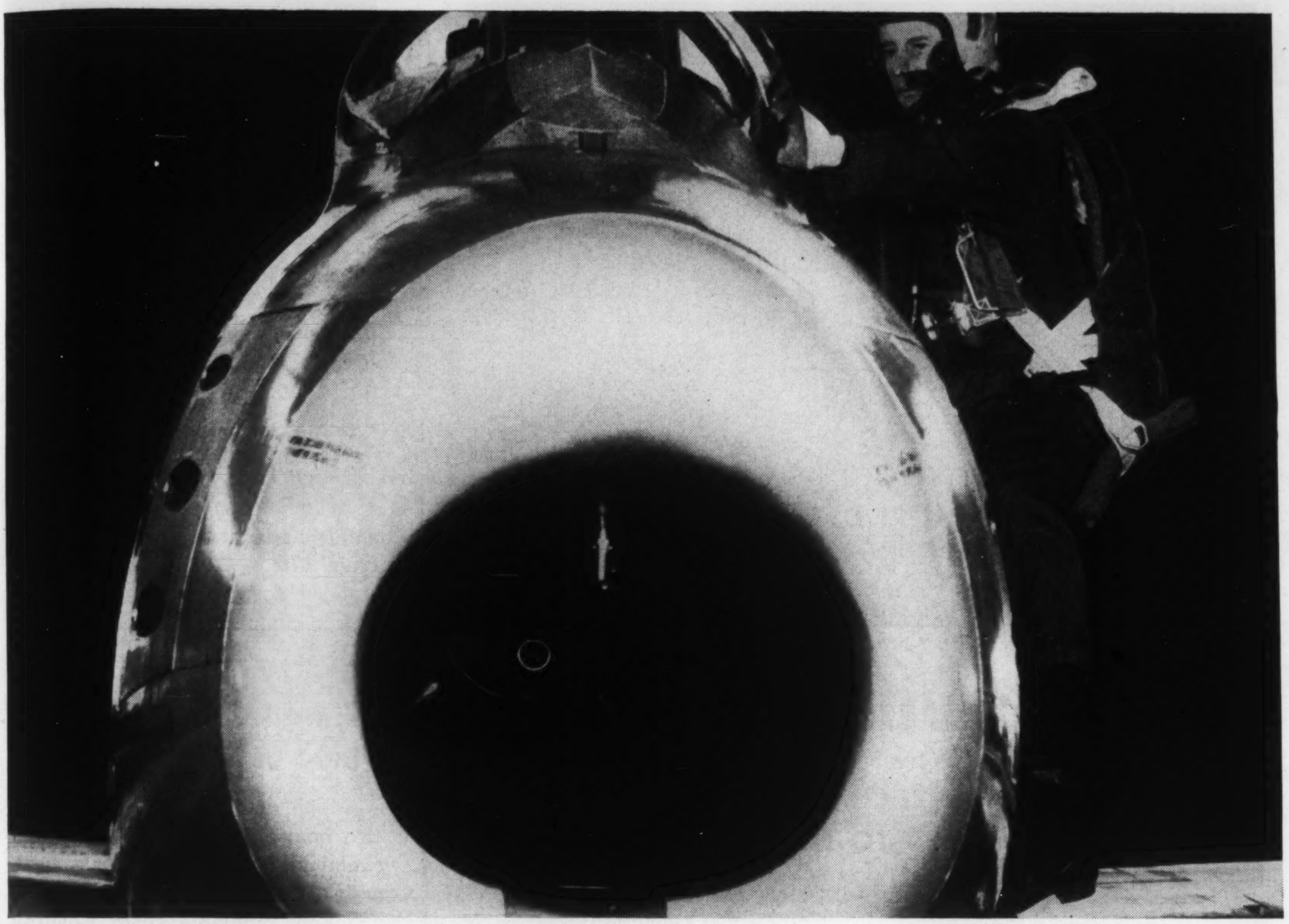
No. 501 is a general purpose, thermosetting potting compound that cures at room temperature. The cured material is a hard solid with good electrical properties and good chemical resistance. It is useful at ambient temperatures up to 200 F.

No. 502 is a high temperature resistant potting compound that cures at temperatures from 150 to 200 F. It is said to have an extremely low coefficient of thermal expansion and very low curing shrinkage. It is usable at temperatures from –100 to 350 F.

No. 503 is a hermetic sealing potting compound that cures at temperatures from 150 to 200 F. It is said to have good resistance to thermal shock at temperatures below 250 F. It adheres well to most metals and to many plastics.

No. 504 is a casting and embedding compound for applications requiring machinability and high temperature resistance. It cures at temperatures from 150 to 175 F and can be used up to 350 F.

No. 505 is an unfilled, general purpose resin that cures at room temperature. It is suitable for use at ambient temperatures up to 200 F and can be used as an adhe-



in here . . . a tough new alloy

Everything this jet fighter swallows hits those buckets and blades, including nuts, bolts, pebbles, rocks, dirt, sticks and even birds.

Often, the result is a ruined engine, a crippled airplane. That's why Carpenter metallurgists devote a good share of their efforts to improving the tough alloys used for compressor and turbine parts and fasteners.

And now, they've come up with a brand new alloy steel—LAPELLOY "C", U. S. Patent No. 2,816,830.

It is more ductile and has more impact resistance than the conventional Lapelloy long used in jet engines. Its structure is more homogeneous and it has more uniform fabrication properties. Its strength is excellent at both room and elevated temperatures.

New LAPELLOY "C" is made by the exclusive Carpenter MEL-TROL process. MEL-TROL makes possible new standards of uniformity and predictable performance in specialty steels by removing the causes of inconsistent centerline quality so often found in alloys made by conventional methods. In addition to new LAPELLOY "C", Carpenter offers a wide selection of other MEL-TROL alloys for elevated temperature service.

Write for technical data on new LAPELLOY "C" and the MEL-TROL process or ask the Carpenter representative who calls on you. The Carpenter Steel Company, 135 W. Bern Street, Reading, Penna.

Carpenter STEEL

Improved alloys for elevated temperature service

For more information, turn to Reader Service card, circle No. 480

NEWS FOR YOU!

positive uniformity

WITHIN EACH BAR END TO END | THROUGHOUT THE ENTIRE SHIPMENT

The most modern **Continuous** roller hearth, radiant tube, Controlled Atmosphere Carbon Correction Furnace is now in operation at our Chicago works. Carbon Correction of decarburized surfaces can be accomplished with a suitable atmosphere during the heating cycle to provide bars for induction hardening applications.

This facility assures you of **uniform microstructure** and **uniform machining** properties.

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QUALITY CONTROL

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For more information, turn to Reader Service card, circle No. 429

sive for metal, glass and thermosetting plastics.

No. 601 is a two-component foaming resin that expands and cures at 225 F. It is recommended for foam-in-place applications where small, tightly packed components are to be encapsulated.

No. 603 is a ready-to-use, single-component foaming resin that expands and cures at temperatures from 175 to 225 F. It is recommended for thermal and acoustic insulation.

Printed Circuit Boards Made of Strong Glass

Copper-metallized printed circuit boards made of Fotoceram, a chemically machinable glass with a flexural strength of 25,000 psi, are now available from Corning Glass Works, Corning, N. Y. (For more information on Fotoceram, see MATERIALS & METHODS, June '56, p 134.)

Copper is metallized on the glass board in one continuous operation without the use of adhesives. The bond of copper to glass is such that the copper runs remain intact after a solder pot immersion of 5 min at 500 F. Corning says the circuit boards are capable of continuous operation at 485 F without sagging or warping, even under the most adverse environmental conditions.

Two Mica Insulations

Minnesota Mining & Mfg. Co., Mica Insulator Div., Schenectady, N. Y., has introduced two types of mica insulation for use in rolled or stacked capacitors for broadcast networks, pulse networks, jet engine and other ignition systems, and power factor correction and filtering applications.

One, called Samica, is a pure mica sheet made from either foreign or domestic mica. Said to be

ANOTHER SUCCESSFUL APPLICATION FEATURING WOLVERINE TUBE . . .

WOLVERINE

IS GOING AROUND IN THE BEST OF CIRCLES . . . WITH

ALUMINUM TUBE

FOR TIGRETT

Lightweight aluminum tube — manufactured the Tubemanship way by Wolverine Tube — plays a leading role in the revolutionary new playpen manufactured by Tigrett Industries of Jackson, Tennessee, and distributed by Thayer, Inc. of Gardner, Mass.

Known as "Play-A-Round", this modern playpen uses aluminum tube as an upper ring to support its enclosing nylon netting and as the lower ring supporting both the floor and netting.

Because Tigrett and Thayer stress the complete safety of their product, it is essential that this aluminum tubing be strong, durable and have a satin-smooth finish. The tubing furnished by Wolverine more than meets these requirements.

Meeting the tubing requirements of American industry is a highly developed specialty at Wolverine Tube. A continuous research program, backed by sound engineering and Wolverine's years of experience, assures tubing designed to meet widely diversified needs.

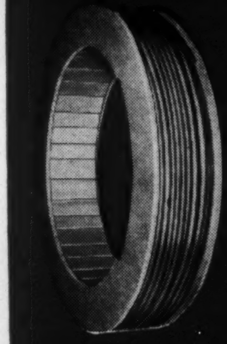
In aluminum, for example, Wolverine manufactures both drawn and extruded tube. For heat exchange purposes, it is available in both finned and prime surface form.

Wolverine also produces extruded shapes and is equipped to provide complete fabrication services. Customers desiring copper or copper alloy tubing can select from a broad range of sizes and alloys in either plain, finned, or fabricated form.

If your company uses tubing—either aluminum or copper—follow the lead set by Tigrett and other leading manufacturers—specify Wolverine on the order form. Write today for your copy of Wolverine's Tubemanship Booklet.

OTHER WOLVERINE ALUMINUM PRODUCTS

PLAIN TUBE
IN STRAIGHT LENGTHS



ON A
LEVEL WOUND
COIL

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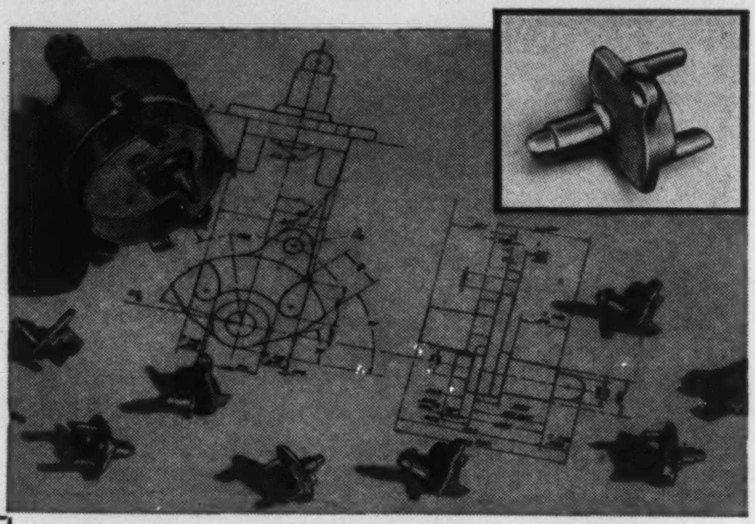
die cast for MALLORY by GRC

helped create higher rated, longer lasting switch



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NO SIZE TOO SMALL!

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Max. length 1¾"

Write for detailed bulletin or send prints for quotation.

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zinc die castings

"Impossible", yes, by *any other* method. BUT—GRC's unique single cavity die casting techniques made possible a detailed and complex actuating mechanism with exceptional requirements of uniformity and accuracy. Inspired Mallory engineers to design a *new and better* switch around this GRC die cast mechanism! Just another instance in which GRC's exclusive patented methods have solved a parts problem and opened the door to a new product . . . at substantial savings.

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Federal Telephone & Radio uses SEL-REX bright gold

to improve electronic component reliability

Sel-Rex Bright Gold is used on a variety of electronic parts at Federal because, to quote Mr. William F. Boyle, Chief Metallurgist, the deposits are "...fine grained and dense, giving exact duplication of the surface plated... (it) eliminates galling in sliding electrical contacts" and has "effected a tremendous saving" over previous materials and methods.

The Federal Telephone story, other case histories and technical data FREE on request.

PRECIOUS METALS DIVISION

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Manufacturers of Exclusive Precious Metals Processes, Metallic Power Rectifiers, Airborne Power Equipment, Liquid Clarification Filters, Metal Finishing Equipment and Supplies.

For more information, turn to Reader Service card, circle No. 441

highly flexible, it withstands temperatures up to 1000 F. The other, called Isomica, consists of a Samica-base sheet impregnated with a special silicone resin. It is said to have good electrical properties at continuous operating temperatures of 550 F and intermittent temperatures as high as 750 F.

Both mica insulations are supplied in rolls 36 in. wide, and in tapes, sheets, strips and punched pieces. They are available in sheet thicknesses of 0.0009, 0.0013, 0.0015 and 0.0020 in.

Glass Fibers Improve Polyurethane Foam

Experiments conducted jointly by National Aniline Div., Allied Chemical Corp., 40 Rector St., New York 6 and Owens-Corning Fiberglas Corp., 598 Madison Ave., New York 22 show that the addition of glass fibers to polyurethane foam increases resilience and compressive strength. The experiments also show that density of the finished foam is not affected when glass fiber up to 5% (by weight) is used, and resistance to humidity is not affected at all. Tensile strength, in some cases, decreases slightly, though not below that of other cellular materials.

The experiments indicate that when one specific property of a

PHYSICAL PROPERTIES OF REINFORCED FOAM

Type ➡	Unreinforced	Reinforced[a]
Ten Str, psi	36	25
Elong, %	515	320
Resilience, %	15	23
Density, lb/cu ft	2.0	2.1
Comp Set, %		
Unaged	19	8
Aged[b]	13	18
Comp Strength, psi		
Unaged	0.46	0.59
Aged[b]	0.35	0.44

[a] Reinforced with 1% (by weight) 1/16 in. long glass fibers.

[b] Aged 7 days at 158 F in 100% RH.

Meat Chef
180
170
160
150
140
POULTRY
FRESH PORK
LAMB, VEAL
BEEF (WELL)
BEEF (MED)
HAM (SMOKED)
BEEF (RARE)
Cooper
DO NOT PUT IN WATER
MADE IN USA

Dependable Consistency of

GENERAL PLATE

TRUFLEX THERMOSTAT METALS

Enables COOPER to Give

Liberal Warranty

The new MEAT CHEF Thermometer by COOPER, featuring the exclusive VISI-DOME DIAL, helps people cook any meat to perfection with ease.

To insure accurate register of roasting temperature Cooper Thermometer Company specifies and uses General Plate Truflex Thermostat Metals, from which they produce coils as shown in enlarged form at the left. Here's what Cooper President, Horace R. Whittier, has to say about it:

Truflex is unvaryingly uniform in operating characteristics, and this enables us to give the liberal warranty we print on each thermometer box.

General Plate TRUFLEX is available in cut strips or long length coils to meet your needs, or can be furnished in formed elements or completed assemblies to meet the most exacting parts specifications. Either way you get accurate consistent performance with TRUFLEX because every repeat order is an exact duplicate of the original — dependably uniform in activity, temperature range, electrical and corrosion resistance.

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foam is to be improved, a glass fiber of suitable length, coating, and percentage in the final formulation can generally be found. However, changes in other physical characteristics must also be considered to be certain they have not exceeded useful limits.

For instance, when high hysteresis losses are desirable, as in impact cushioning, the properties can be achieved by adding 5% of 1/32 in. milled glass fibers. The resulting finished polyurethane foam will have high compression strength and low elongation. The material offers sustained resistance and rebounds slowly, making it an excellent shock absorber.

New Polyurethanes Withstand 300-400 F

Two polyurethane products having substantially improved physical properties at high temperatures have recently been developed. The development of these two new products—one a solid elastomer and the other a foam—should open up a whole new temperature range for these highly versatile materials.

Heat resistant rubber

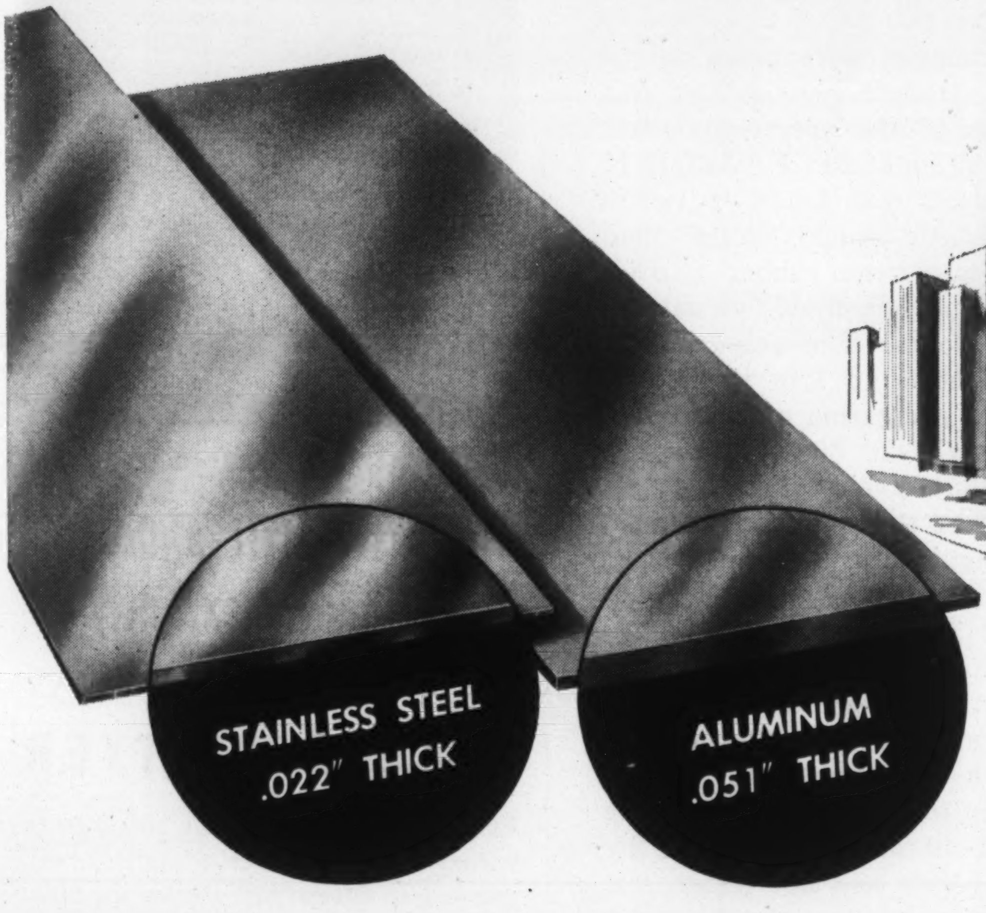
One product, a polyurethane rubber called Genthane S, is available in pilot plant quantities from General Tire & Rubber Co., Chemical Div., Akron, Ohio. Products made from the new rubber are said to have remarkable stability at temperatures up to 300 F and to have good resistance to hydrocarbons, oxone and oxygen.

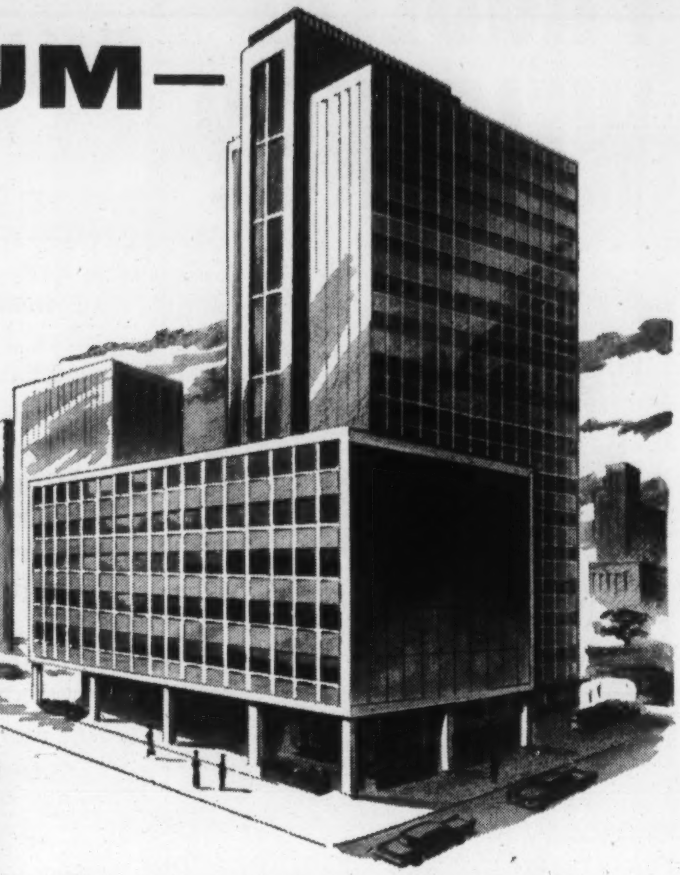
In tests conducted at General Tire, no degradation was observed in Genthane S specimens after

PROPERTIES OF GENTHANE S

Tensile Strength, psi	3630
Elongation, %	590
Durometer Hardness	A 66
Compression Set (22 hr, 158 F), %	18
Crescent Tear Strength, psi	225
Yerzley Resilience, %	66
Brittle Point, F	<−20

STAINLESS COSTS LESS THAN ALUMINUM—





Do you know that the square-foot cost of stainless steel sheet for curtain wall panels is usually equal to or lower than aluminum when compared in thicknesses of equal indentation resistance? For example, Type 302 stainless steel, .022″ thick is equal to .051″ aluminum and costs only 62¢ per sq. ft., as compared to 67¢ per sq. ft. for 3003-H14 anodized aluminum.

For additional information on all gauges, fill in and mail the coupon.

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Gentlemen:
Please send me full information on comparative costs of stainless steel vs. aluminum for curtain wall panels.

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P&H Low-Hydrogen electrodes give you industry's widest choice of alloys for welding "difficult" steels. There's a chemical analysis to match most parent metals.

Welds are of X-ray quality, with greater ductility at high tensile strength, and better impact properties. For more detailed information, write for Bulletin R-29, Dept. 301G, Harnischfeger Corp., Milwaukee 46, Wisconsin.

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aging for 200 hr at 212 F; only slight changes were noted in the tensile strength, elongation and hardness of the specimens after aging 200 hr at 250 F. At 300 F, Genthane S was found to retain its strength much longer than styrene-butadiene rubber (SBR), chloroprene (neoprene) or natural rubber stocks. The polyurethane rubber seems to lose its tensile strength, elongation and hardness very slowly at 300 F, whereas styrene-butadiene stocks lose almost all of their tensile strength and elongation in a few hours.

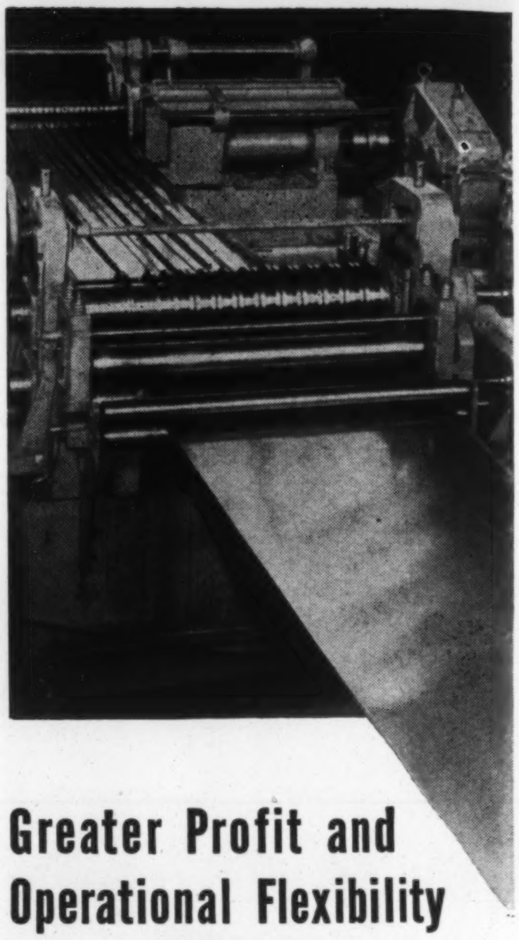
According to the producer, Genthane S does not have a useful life at 350 F; at this temperature degradation is severe.

General Tire says Genthane S compares favorably with nitrile rubber in its resistance to oil. The material is usually attacked by polar solvents and hot water, but it is said to give excellent service when in contact with either paraffin or aromatic hydrocarbons. The polyurethane rubber is useful at temperatures as low as –20 F or below.

Heat resistant foams

At a recent meeting of the Isocyanate Symposium of the Society of Plastics Engineers, held in Minneapolis, Minn., V. V. D'Ancicco, Garwin Polymer Products, Inc., North Haven, Conn., described his company's work in the developement of heat resistant, rigid polyurethane foams. The rigid foams are based on a new polyisocyanate component called polymethylene polyphenylisocyanate, trade named "Papi" by the company.

Mr. D'Ancicco says Papi-based rigid foams can retain 70% of their room temperature strength at temperatures as high as 400 F with a shrinkage of only 2%. He says this represents an increase of more than 150 F over the useful temperature range at which conventional polyurethane foams can function. In his paper, Mr. D'Ancicco outlined a number of


Greater Profit and Operational Flexibility with a YODER SLITTER

Even if you use less than 100 tons of varied strip sizes per month, it will pay you to investigate the savings that are possible through the operation of a Yoder slitter. Savings per ton increase rapidly as coil size and width of strands decrease...so much, that under average operating conditions, a slitter will pay for itself in a few months.

From a small stock of standard mill-width coils, a Yoder slitting line enables you to meet unexpected demands, or to supply "special" width slit strands in a matter of a few hours. This flexible operation increases plant efficiency, resulting in savings of time and money through simplified production planning and greatly reduced strip inventories.

The Yoder line includes slitters of every size and capacity for coil or sheet stock. Send for the all-new, 1958 edition of the Yoder Slitter Book. It is a comprehensive text on the mechanics and economics of slitter operations with time studies, cost analyses, and other valuable data. Write to:

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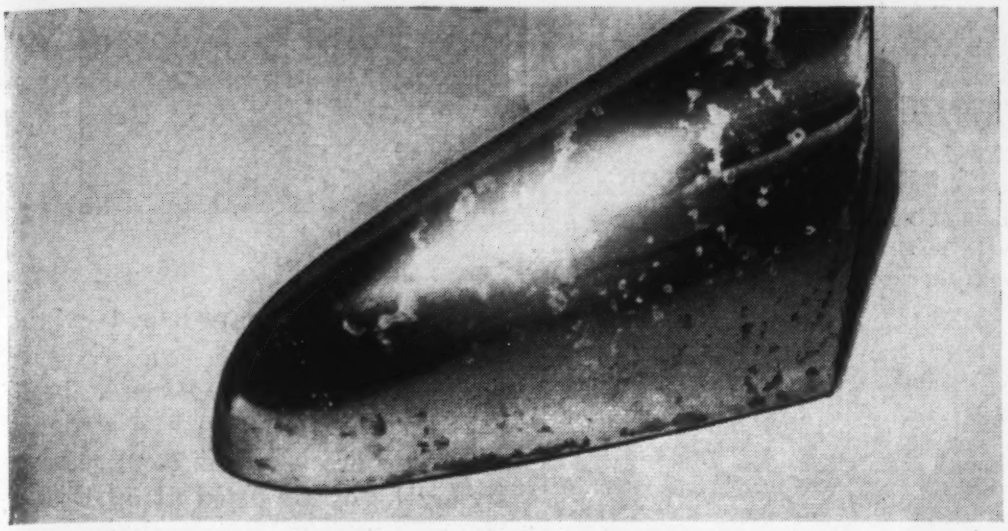
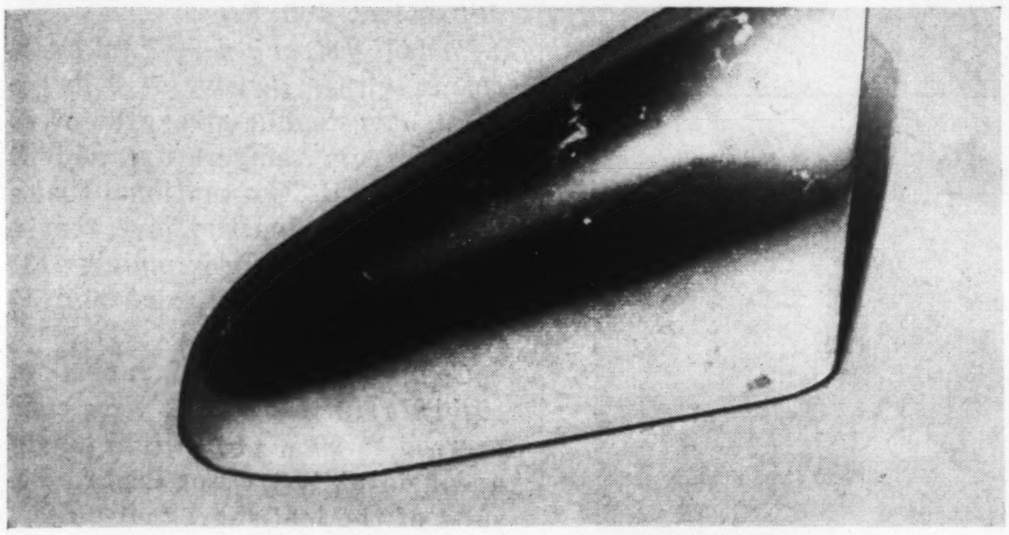
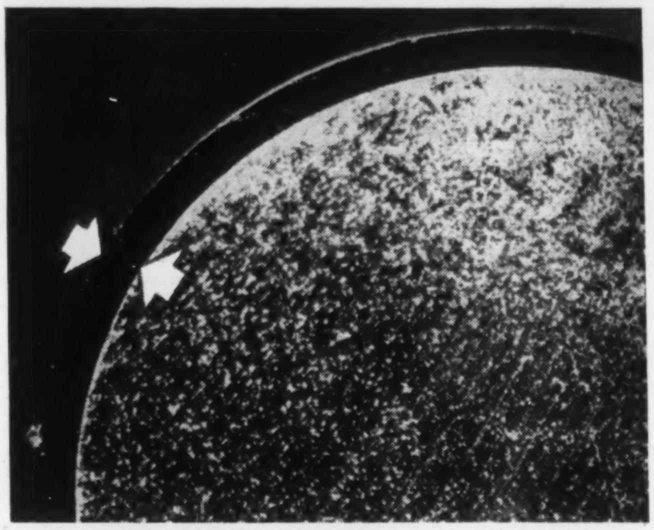
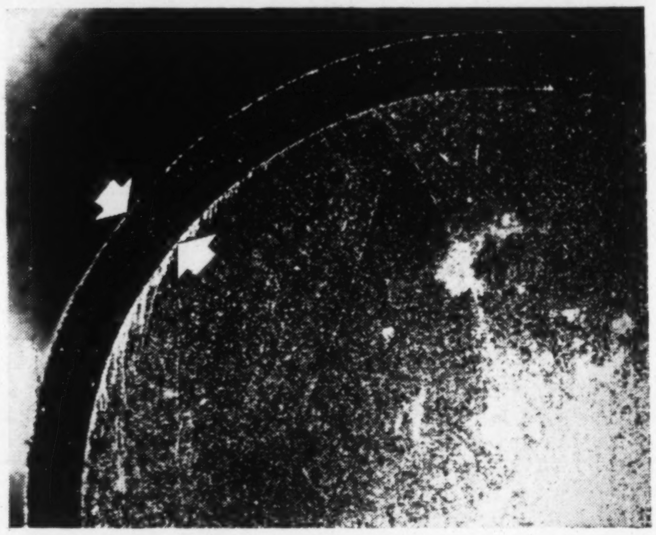




UNICHROME BRIGHT CRACK-FREE CHROMIUM MADE THIS DIFFERENCE IN PROTECTION. Photographs show results of 72 hour acetic acid salt spray test. Part at top was plated with ordinary chromium according to automotive manufacturer's specifications for copper, nickel, chromium finishing. Part at bottom had same copper and nickel deposits but Unichrome Crack-Free Chromium replaced the ordinary chromium, thus greatly increasing corrosion resistance.





UNICHROME SRHS® CHROMIUM MADE THIS DIFFERENCE IN THICKNESS. Enlarged cross sections of identical steel rods show ratio of thickness of plate from ordinary chromium solution (top) to thickness from SRHS Chromium Solution (bottom) . . . a much thicker deposit in the same plating time!

How to get more corrosion resistance from chromium plate

When consumers find fault with decorative chromium plate, it's generally due to early corrosion.

This trouble starts with pores and cracks that occur in all ordinary chromium in the range of thicknesses generally used for decorative plating. Road chemicals, salt atmosphere and fumes find a path right down to base metal. Corrosion starts. As corrosion increases, finish failure progresses, allowing still more corrosion.

But you can stop this at the source.

THICKER, CRACK-FREE CHROMIUM

Chromium itself is passive. It doesn't corrode. Eliminate pores and overcome its cracking and you greatly improve its corrosion *protection*. Pores are eliminated by thicker plating. To overcome cracking, use the Unichrome Bright *Crack-Free* Chromium Process. This deposit is free from corrosion-admitting cracks. It has already been used in automotive production for a year.

MINIMIZE PRODUCTION PROBLEMS

Unichrome *Crack-Free* Chromium is far superior to ordinary chromium not only in protection, but also in operating advantages. The solution is self-regulating. It offers improved throwing power, also better coverage — even over passive nickel.

TO PLATE THICKER CHROMIUM

For those who desire thicker deposits but do not require freedom from cracking, other Unichrome self-regulating processes offer distinct advantages. They plate up to 80% faster than ordinary chromium plating processes. They cover parts with less dulling or burning, are less susceptible to clouding due to current interruption. Control is simplified by their self-regulating features.

Whichever process is best for your products, Metal & Thermit has over 30 years of service experience to help you make it work. Call in an M&T plating engineer to survey your requirements, tell you what's needed for the results you want. Or, send for Bulletins.

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"Wear parts" made from KENNAMETAL help keep production high, downtime low

Against $(NH_4)_2SO_4$

KENNAMETAL* components last 2 to 6 times longer...

On Unloader Knives: When processing corrosive Ammonium Sulfate (Coke Plant), the best life of any material tried for unloader knives on this crystal dehydrator was less than three months.† With Synthetic Ammonium Sulfate, the knives lasted little more than a month. By changing to knives made from Kennametal hard tungsten carbide, service life has been increased to twelve months or more with Coke Plant Sulfate, and up to four months with Synthetic Sulfate.

On Distributor Tips: With sulfates of either kind, Kennametal Distributor Tips in the feed assembly last up to eight months—double the life of any other alloys tried. Kennametal parts cost less in terms of longer life, increased production, and less downtime.

Chances are Kennametal can help *you* solve a problem involving corrosion, abrasion, erosion, or contamination. The Kennametal "family" of hard carbides includes grades three times as rigid as steel . . . grades that last up to 60 times as long as steel . . . grades that retain high strength at 2200°F and above or at subzero temperatures.

Let us tell you more about Kennametal and how it has helped others solve problems that may be similar to yours. Write to KENNAMETAL, INC., Dept. MDE, Latrobe, Pennsylvania.

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*Trademark
†Based on an average daily throughput of 100-150 tons.

INDUSTRY AND KENNAMETAL ...Partners in Progress

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properties of Papi-based rigid foams.

Compressive strength—A Papi-based rigid foam with a density of 18 lb per cu ft has compressive strengths of 1000 psi at 50 F and 500 psi at 400 F; another Papi-based foam with a density of 10.5 lb per cu ft has compressive strengths of 250 psi at 50 F and 180 psi at 400 F.

Tensile strength — Papi-based foams with a density of 6 lb per cu ft have tensile strengths of 80 psi at room temperature and 30 psi at 400 F. Conventional foams of the same density have tensile strengths of approximately 180 psi at room temperature and 10 psi at 325 F.

Compression set—Samples of rigid Papi-based foams were compressed to 90% of original height and held at 158 F for 22 hr. Results of the test show that a foam with a density of 13 lb per cu ft has a compression set of 5.3%, and a foam with a density of 3.5 lb per cu ft a compression set of 4.2%.

Unique Test Method Gives Corrosion Rates

New information that may lead to more advantageous selection of existing corrosion resistant materials as well as the development of new corrosion resistant materials is expected to be uncovered as a result of a new method of determining the corrosion rate of metals.

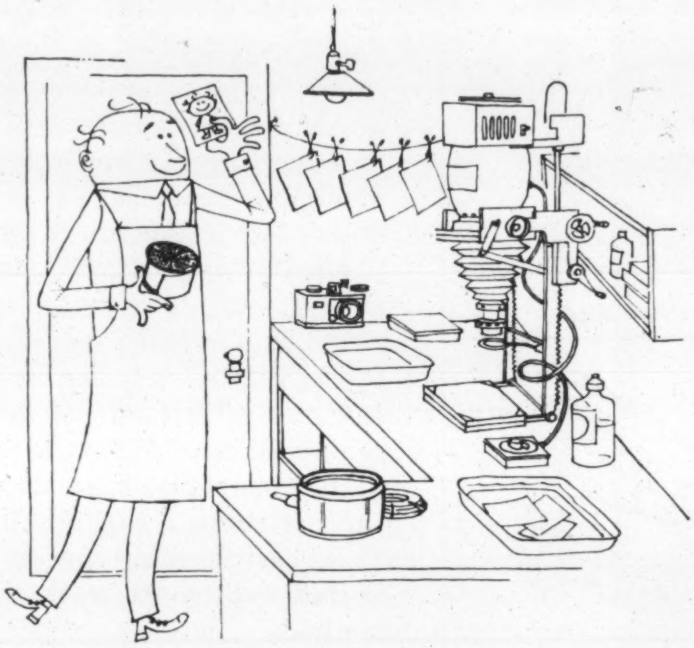
The new method, presently being used by Carpenter Steel Co. in its new corrosion research laboratory (see p 183), makes use of two unique pieces of equipment:

1. A "Corrosometer." This is an extremely precise instrument which measures the corrosion rate (in terms of microinch penetration) as a function of changes in electrical resistance of a given specimen. Here's how it works: Comparative electrical resistances

From the Dow family of plastics . . . look to

STYRON

and its variety of highly moldable formulations



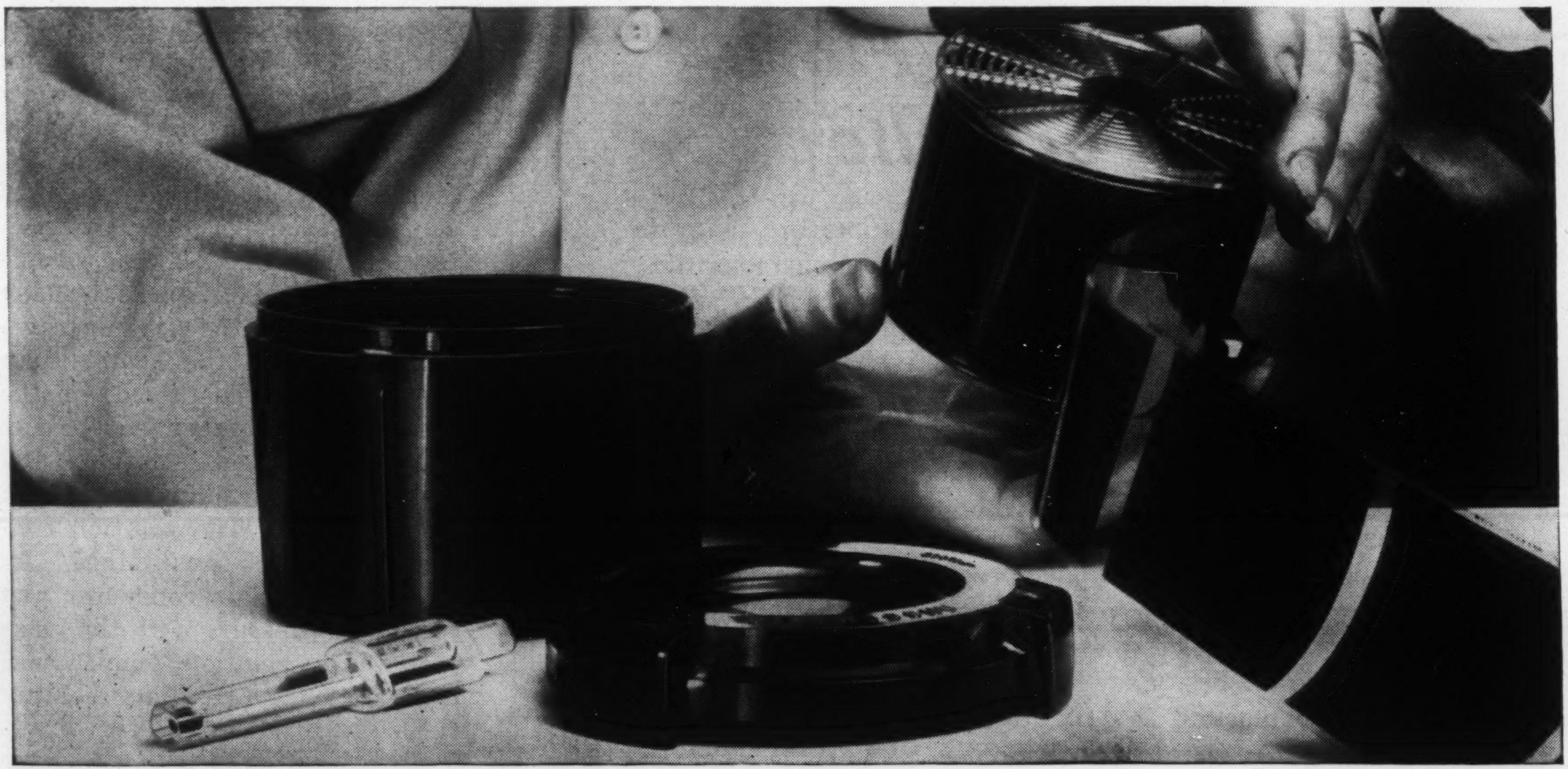
This photo developing tank would be a nightmare for the molder if it weren't for versatile Styron*.

Four different Styron formulations were employed, all of which have two things in common: exceptional moldability and unyielding resistance to chemicals commonly used in photographic processes. The tank wall and cover are Styron 700 in a special opaque camera black, selected for its high gloss finish and heat resistance. Styron 475 was used for the integrally molded center shaft and lower reel because of its excellent strength and ease of fabrication.

The crystal clarity and easy moldability of Styron 666 were put to good use in the upper reel. For one of the most difficult molding assignments—the thermometer-agitator rod—Styron 689 with its exceptional flow characteristics for intricate molds was chosen.

You get advantages like these with each member of the Dow family of thermoplastics. See your Dow man soon. THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1534D-1.

*Trademark of The Dow Chemical Company



From developing tanks to pipe linings—

Dow plastics lead the way

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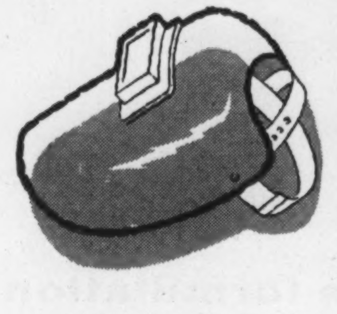
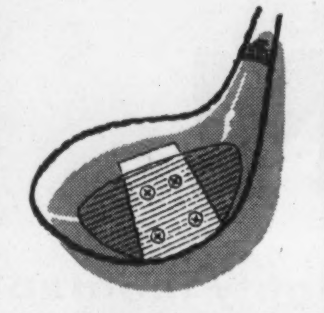
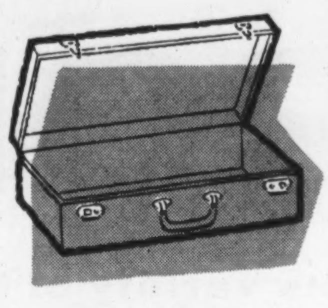
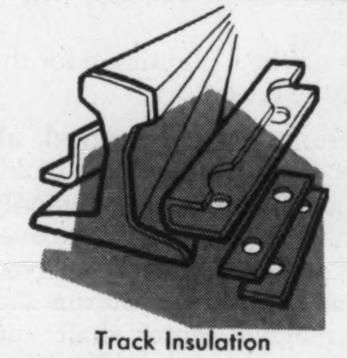
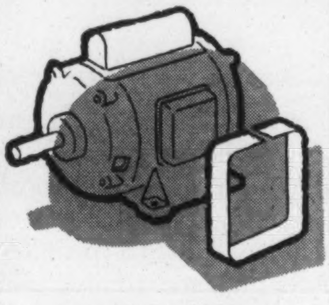
A few typical applications of Taylor Vulcanized Fibre

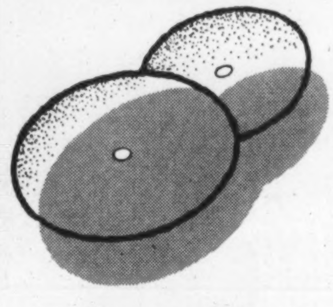

Welders' Helmets

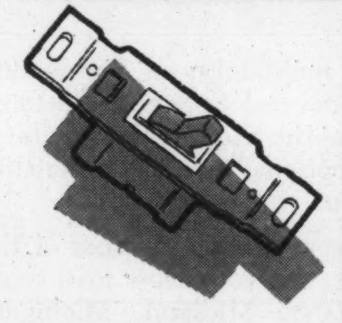

Golf Club Face Inserts

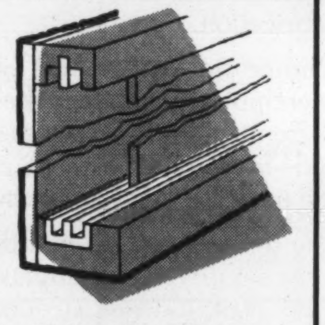

Carrying Cases

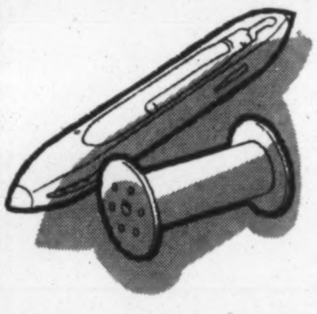

Track Insulation


Motor Insulation


Abrasive Discs


Switch Parts


Sliding Door Guides


Shuttles and Bobbin Heads

Vulcanized Fibre Is Versatile

The applications of Taylor Vulcanized Fibre are many in number. This is because of its many unusual characteristics. It is a hard, dense material with excellent physical, mechanical and electrical properties. It is tough and resilient; has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline; it can be machined, stamped, punched and formed; it is attractive in appearance, light in weight.

Taylor Vulcanized Fibre is available in a number of different grades, in sheets, rolls and turned rods. Undoubtedly you have an application where the unique properties of vulcanized fibre can be put to work in your product. A Taylor application engineer will be glad to discuss requirements with you and recommend the best grade to fit them. Get the benefit of his advice by contacting Taylor Fibre Co., Norristown 41, Pa.

Taylor
LAMINATED PLASTICS VULCANIZED FIBRE

For more information, turn to Reader Service card, circle No. 470

of specimens with known cross sections are measured and the samples subjected to corrodents. The Corrosometer then plots changes in electrical resistance—and thus the differences in corrosion resistance—as a function of the reduced cross section produced by corrosion.

According to Carpenter, the instrument provides an important means of comparing alloys for particular applications, evaluating the effects of specific contaminants on corrosion rates, checking the effects of velocity and checking the effects of variations in temperatures. What is perhaps most important, however, is that the instrument can obtain in 24-48 hr results that previously required two to six weeks by other methods.

2. Heat transfer test equipment. This unique piece of equipment, an exclusive Carpenter development, is said to predict corrosion rates of metals used in heat exchangers more accurately than any test method presently being used in the steel industry. Here's how it works: A small sample is clamped over an opening in a glass vessel. The sample is then electrically and externally heated, so that the heat is transferred through the sample into the corrodent contained in the vessel. The corrodent may be any aqueous chemical solution, and test temperatures may range from 140 to 390 F. The solution concentration is maintained by means of a reflux condenser and control of pressure with the glass vessel. The solution temperature is regulated by auxiliary heating elements surrounding the glassware. Corrosion is determined by weight loss measurements on the sample.

According to Carpenter, the rates obtained are more accurate than those obtained through standard boiling tests because: 1) the sample and solution are at

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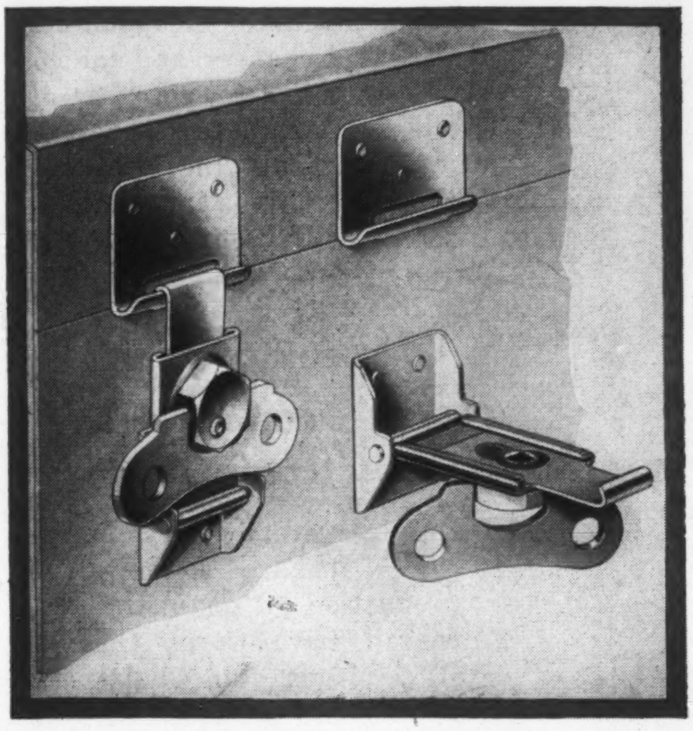
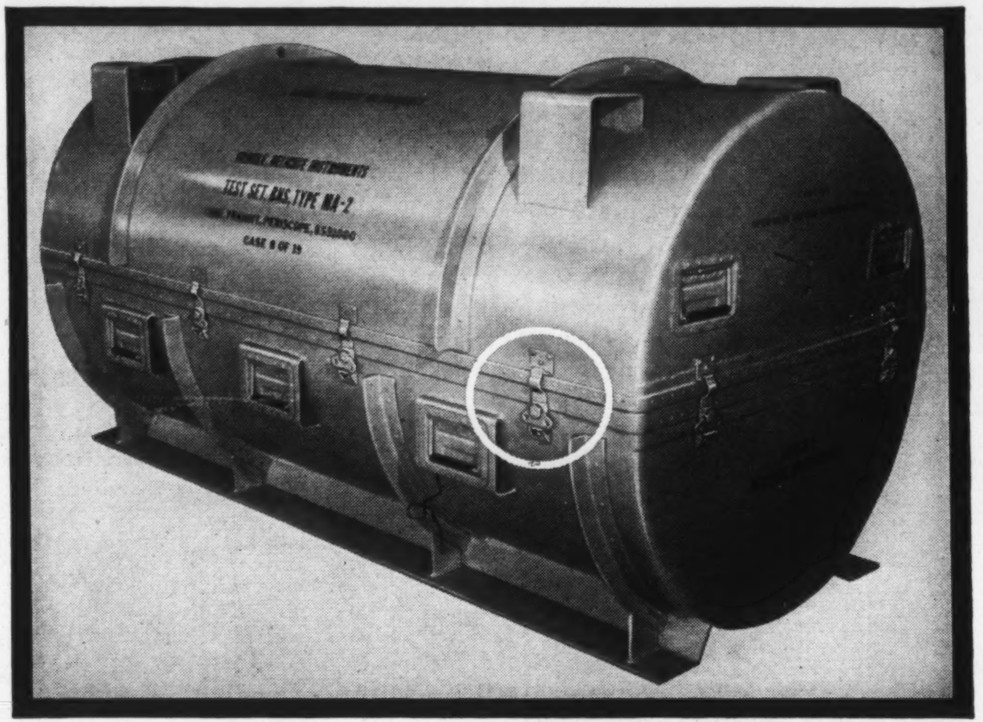




Photograph courtesy of Craig Systems, Inc.

LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

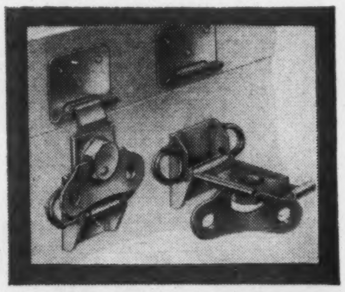
Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Danvers, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design... lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.



Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

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See our 8 page catalog in Sweet's 1958 Product Design File

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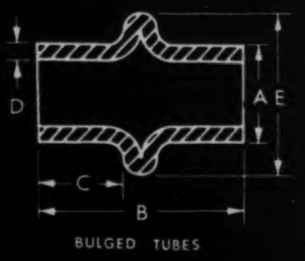
We are equipped for precision production of parts cut, flared, flanged, and bulged from tubing.

Original wall thickness is maintained in the finished parts with square ends and they vary from no burr to a maximum burr of .001" on the I.D. or O.D.

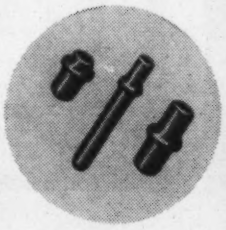
Improve your own production efficiency and reduce your assembly costs with uniform tubular components.

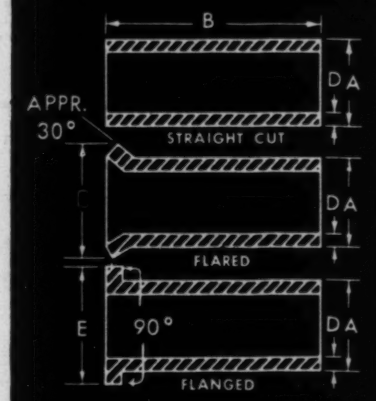
Eliminate secondary operations and tooling costs by specifying tubing.



BULGED TUBES

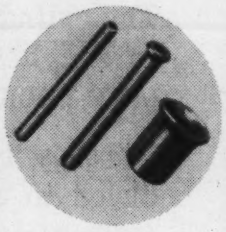
A	B	C	D	E
.040	.125 TO .625	.040 TO .500	.005	.060
.050			.007	.075
.060			.010	.090
.075			.010	.110
.090			.010	.120
.125			.010	.160
.156			.010	.200

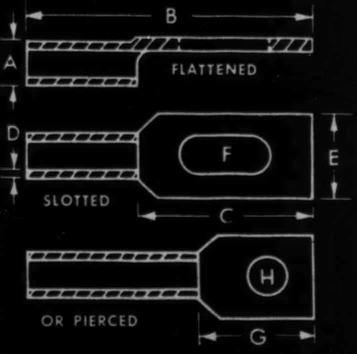




STRAIGHT CUT, FLARED, FLANGED

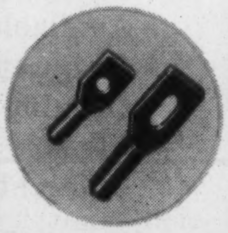
A	B	C	D	E
.040	.090 TO 1.250	.050	.005	.055
.050		.060	.007	.070
.060		.075	.010	.080
.075		.090	.010	.100
.090		.115	.010	.115
.125		.160	.010	.170
.156		.185	.010	.200





FLATTENED, SLOTTED, OR PIERCED

A	B	C	D	E	F	G	H
.040	.250 TO .688	.185 TO .230	.005	.070		.125 TO .156	.045
.050			.007	.090	.045 X .120		.060
.060			.010	.105	.055 X .120		.062
.075			.010	.120	.060 X .125		.075



OVER 500 MILLION KLEINER parts have been produced and accepted by electronic manufacturers. Consider tubular parts when designing for automation and miniaturization.

KLEINER METAL SPECIALTIES INC.
P. O. BOX K, DUNELLEN, NEW JERSEY

For more information, turn to Reader Service card, circle No. 428

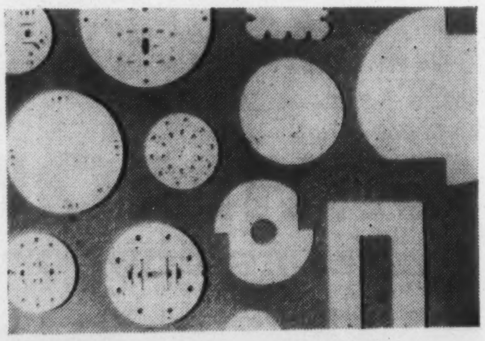
different temperatures, thus simulating the actual relationship that exists between the metal walls of a heat exchanger and the corrodent it handles; and 2) edge effects are eliminated as a result of exposing only the surface of the sample. This is important because in actual service the edge is rarely exposed to corrosion attack.

Thin Ceramic Parts for Electronic Devices

Alumina ceramic parts as thin as 0.005 in. are now available in production lot quantities from American Lava Corp., Cherokee Blvd. & Mfgrs. Rd., Chattanooga 5, Tenn. The producer says the parts are dimensionally accurate and are so thin they are actually translucent. In electron tube applications, the ceramic parts are said to: 1) withstand high degassing temperatures; 2) reduce damage from fatigue failure and heat deterioration; and 3) eliminate emission losses caused by high temperatures, shock and vibration.

American Lava says the ceramic parts are satisfactory for micro-wave windows, transistor platforms, insulators for hearing aids, radio crystal cages, tinkertoys for high temperature amplifiers, high temperature relays, transformers and fuses.

(more What's New on p 160)



Electron tube parts *made of alumina ceramic are said to extend the operating temperature range of the completed tube.*

This Sandusky Centrifugal Casting—one of four produced for Westinghouse Atomic Equipment Department—meets radiographic, intergranular corrosion, and all other rigorous chemical and physical tests.

ONE
SANDUSKY
CENTRIFUGAL
CASTING ...makes 4 giant stator shells

Specified by Westinghouse for 4 canned motor pumps soon to be integral parts of reactor system in Yankee Atomic Electric Plant in Rowe, Massachusetts

One king-size 17-ton Sandusky casting supplied the main motor bodies (stator shells) for the four pumps being built by Westinghouse, each to handle 23,600 g.p.m. of pressurized water through the reactor core.

The 25-foot-long Sandusky casting was centrifugally spun of a modified CF-8 (Type 304 L) stainless steel, then machined by Sandusky to a 3″ wall thickness, 31½″ on the O.D. This huge casting was hydrostatically tested to 3800 psi before being sectioned into four 68″ lengths.

These stator shells represent another *new and exacting application* for Sandusky Centrifugal Castings—which may offer a practical and economical answer to *your* cylindrical requirements also. They are available in diameters from 7″ to 54″—in lengths up to 33 feet—in heat- and corrosion-resistant stainless, carbon and low-alloy steels and a wide range of copper-base and nickel-base alloys.

Let us show you how Sandusky Centrifugal Castings can help solve your cylindrical problems. Write to us at Sandusky, Ohio.

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.
SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

For more information, turn to Reader Service card, circle No. 473

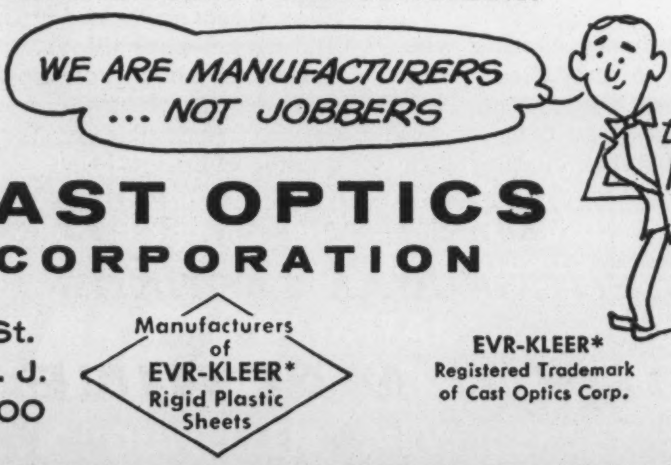
HARDER SURFACE! HIGH RESISTANCE TO SCRATCHING... TO CHEMICAL AND ACID ATTACK... TO IMPACT AND HEAT
ACID

RIGID CR-39
OPTICALLY CLEAR
PLASTIC SHEETS

It's superior to any other plastic! If you need an optically clear, rigid, thermosetting plastic sheet that looks like plate glass yet is half the weight, specify CR-39—has greater resistance to impact, crazing, chemicals, acids, wear, abrasion and weathering. Here are some of the hundreds of uses for this amazing plastic:

- **Protective lens for welding helmets**
- **Instrument dials, panels and windows**
- **Plastic mirrors**
- **Plotting surfaces**
- **Photographic filters**
- **Marine windows**
- **Safety guards and goggles**
- **X-ray equipment and accessories**
- **Projection slides**

We can supply in sheet form, thicknesses from .020 to .500, or precision-fabricate and cut to your exact needs. Write or phone today for complete details, specifications and samples of CR-39. WE ALSO MANUFACTURE **EVR-KLEER** RIGID CAST ACRYLIC PLASTIC SHEETS AND OTHER SPECIAL FORMULATIONS.


WE ARE MANUFACTURERS ... NOT JOBBERS

CAST OPTICS
CORPORATION

550 Newman St.
Hackensack, N. J.
HUbbard 9-4000

Manufacturers of EVR-KLEER* Rigid Plastic Sheets

EVR-KLEER* Registered Trademark of Cast Optics Corp.

For more information, turn to Reader Service card, circle No. 458

Silicone Fluid Operates Between -40 and 500 F

A methyl phenyl silicone fluid is now available which will withstand more than 1000 hr exposure to air at 485 F without decomposing or gelling. It is produced by Silicone Products Dept., General Electric Co., Waterford, N. Y. Designated 81705, the fluid can be used for a variety of applications over the temperature range of —40 to 500 F.

Because of its temperature and oxidative stability, 81705 is suggested as a heat transfer medium in thermostatic controls and in high temperature instrument calibration and oil sterilization baths. Its low power factor and a dielectric strength exceeding 30 kv suggest its use as a liquid dielectric for capacitors, condensers and small transformers.

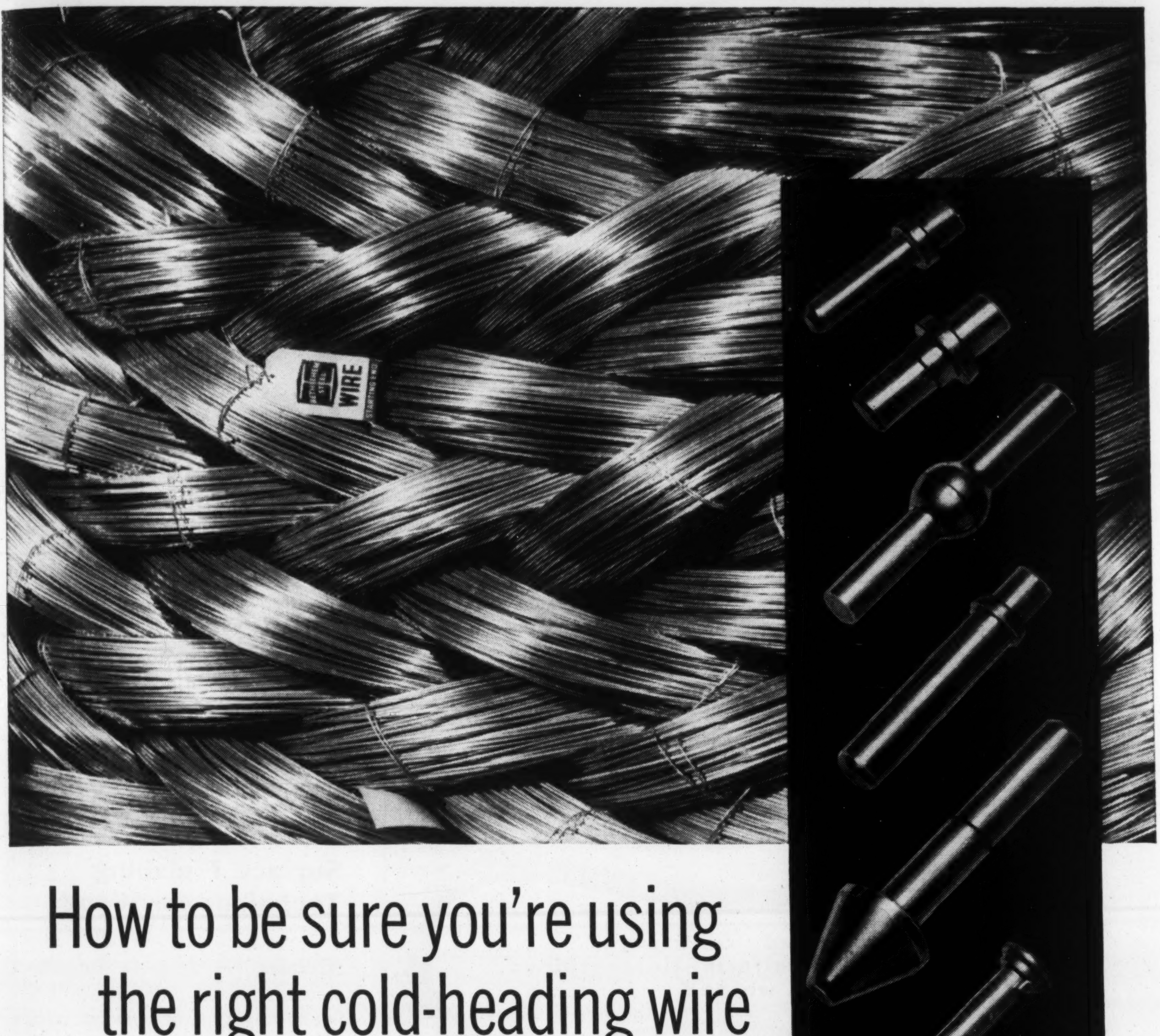
The fluid can also be used as a high temperature lubricant for instruments, clocks, timers, thermostats, oven doors and conveyor bearings. The company says it is an excellent lubricant for sliding and rolling friction with hardened steel and other materials including bronze, copper and nylon.

Reinforced Plastics Are Strong at 500 F

Two fiberglass-reinforced plastics materials have been developed by Mesa Plastics Co., 11751 Mississippi Ave., Los Angeles 25, Calif., for high temperature applications.

Diall FS-4, a long fiberglass-filled diallyl phthalate molding compound, has a flexural strength of 6700 psi, a compressive strength of 6500 psi, and a tensile strength of 4270 psi at 500 F. The plastics compound sells for $1.75 per lb.

Diall FS-5, a short fiberglass-filled diallyl phthalate molding compound, has a flexural strength of 2000 psi, a compressive strength of 6000 psi, and a ten-



How to be sure you're using the right cold-heading wire

It pays to be fussy about the grade of cold-heading wire you use in operations like upsetting, forging or roll-threading. The job is half licked when you start with the correct type of steel wire.

Steel wire for cold-heading is a Bethlehem specialty. There are many ways in which our experience might prove helpful in bettering your production of cold-headed items.

At your invitation we will gladly study your products, equipment and process . . . and recommend the grade of steel that will perform the best. Then we'll carefully produce the steel to meet your needs.

Bethlehem cold-heading-quality wire is made to rigid standards. It is uniform in analysis and free from injurious surface defects. Thorough inspection at every stage of production typifies the quality-control that's behind every ton we ship.

One of our technical men will be glad to discuss cold-heading with you—or any other application of steel wire. Bethlehem makes nearly all kinds of steel wire. Just phone the nearest Bethlehem sales office, or drop a line to the address below.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

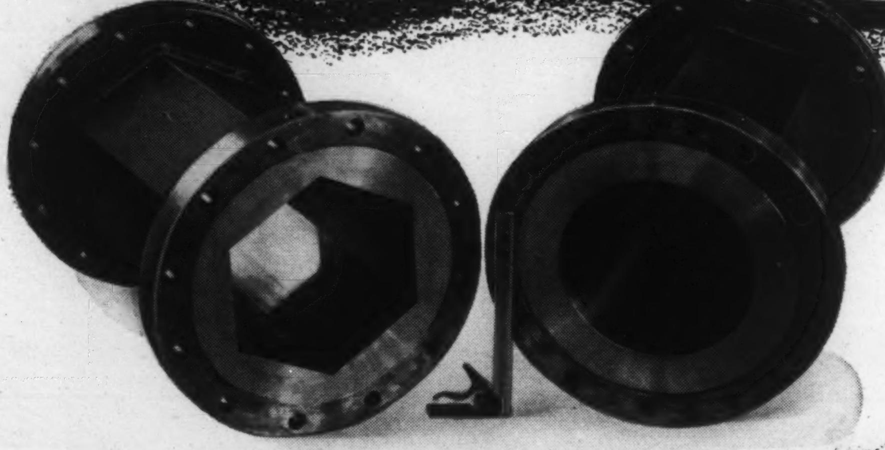
BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 453

DURASPUN

18-8 Centrifugal Castings



...specified "centrifugal" because uniform, close-grained metal was wanted

These castings are sections of a special fractionating column, cast and flanged as illustrated at the right; machined and finished at the left.

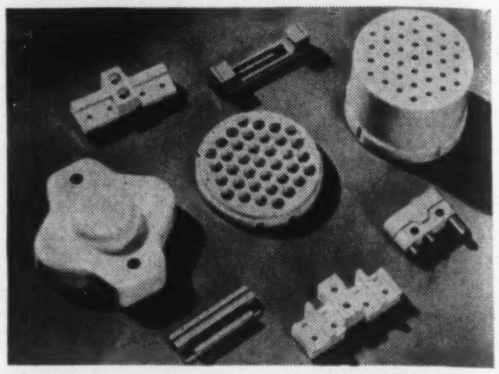
Why **centrifugal** castings, you ask?

Specifications called for an exceptionally close-grained, uniform metal structure free from blowholes of any sort on the inner face. Centrifugal castings assure this superior metal structure.

Our service to industry is two fold: centrifugal castings and static castings, produced in one of the most modern and best technically controlled foundries in the country. Why not try Duraloy for your next high alloy casting requirement?

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 481



***Electrical parts** manufactured from fiberglass-filled diallyl phthalate molding compounds.*

sile strength of 4500 psi at 500 F. It sells for $2.75 per lb.

Both materials are said to have good resistance to fungus, solvents, acids and alkalis. They are also said to have good dielectric strength, high arc resistance, low dissipation factor and low water absorption.

Surface Finishing Technique for Wood

A machine process called Super Microseal is said to impart a smooth, glossy, mar resistant finish to any type of wood at a rate of 90 to 120 linear ft per min. Developed by Satin Surfaces, Inc. (subsidiary of General Plywood Corp.), Louisville, Ky., the process will be licensed to wood products manufacturers throughout the world.

The technique uses pressure and friction to create heat which melts lignin, a natural plastic in the wood's surface. This is blended with a synthetic resin especially developed by Reichhold Chemicals, Inc., White Plains, N. Y., for use with the machine process. The two together are said to form a dense, extremely smooth, mar and water spot resistant surface about 1/24 in. deep. The surface is not a film or overlay, but actually part of the wood.

The producer says the process eliminates hand sanding, sealers

THIS IS GLASS

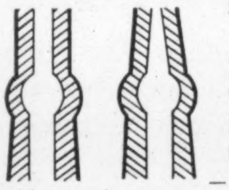
a bulletin of practical new ideas from Corning

Hot tip!

This is a *glass* welding torch nozzle. You'll find them used on the inert gas welding rigs made by a number of up-to-date manufacturers.

Main reason for the *switch* to glass? You can keep close *watch* over the weld, *avoid* the kind of mistakes that can run into big money when you're working on expensive alloys.

Some of these welding nozzle tips are made out of VYCOR brand glass No. 7913, a 96% silica glass that's been *degassed*. Special firing to remove moisture reduces the tendency to deform at high operating temperatures.



All glass welding tips are fashioned from heavy-wall tubing that could be held as close as ±.001″. Also, some pretty fancy machining and forming goes into them. One type calls for precision grinding of an outside taper, another for the same treatment on the inside—both for friction locking. And the tip we make for one firm has a bulb-like configuration to increase gas turbulence. All tips are fire-polished for added strength.

From all we've been able to discover, the men in the shop are quite enthusiastic about these rugged, heat-resistant glass tips that let them watch the welds go by. Likewise for the people who buy these tips from Corning and sell complete rigs to welders. They get what they need, when they need it, at a price that makes sense.

Special glasses, along with special techniques for either custom or mass production, await your appraisal. Which brings us to a standing offer: Bring us your knotty problem—product or process—and we'll see if we can't come up with a *glass* answer.

Or put some data at your fingertips by sending for Bulletin B-91, "VYCOR brand industrial glassware by Corning." In it you'll find all facts about infrared and ultraviolet transmission, heat and chemical resistance, and forms in which you can get these glasses.

How not to foul up the works

It's really very simple: If you're using spun insulation in electric motors, you have to keep the stuff from falling into the moving parts and fouling up the works.

Two things to keep in mind when selecting a material for this application: (1) It has to stand up to quite a bit of heat. (2) It *can't* be a conductor.

Some materials that are good insulators can't take the heat. Others function well at high temperatures but are not insulators.

Glass solves both problems. So, people who make electric motors build them with wedges made from PYREX brand glass No. 7740. (We supply the glass in rod form.)

This particular PYREX brand glass offers a number of useful characteristics. It is corrosion resistant and has a linear coefficient of expansion of 32.5 x 10^{-7} in/in between 0° and 300°C. Dielectric properties at 1 Mc and 20°C. are as follows:

Power factor	.46
Dielectric constant	4.6
Loss Factor	2.1

Wedges made from glass rod support spun insulation in electric motors. Glass is non-conducting and able to stand high temperature without deforming.

You can get PYREX brand glass No. 7740 in a variety of forms—pressed ware, blown ware, plate, tubing, rod and panels.

Mechanical, thermal, electrical, and chemical properties of this glass and 27 others are spelled out in Bulletin B-83. Check the coupon for a copy. Also ask for IZ-1, "Designing With Glass for Industrial, Commercial and Consumer Applications."

Blues in the white

Grand Coulee Dam is quite an impressive sight. It stands 550 feet high, and 4,173 feet wide. At night it's illuminated by 686 high wattage floodlights, covered with *colored front lenses*.

These lenses are red, green, blue, and yellow. And part of the lighting plan requires making *white* by *adding* red, green and blue.

That's where the trouble started. The equipment manufacturer required a very *precise* shade of blue. And despite years of experience in making colored glass, Corning had no blue on hand to do this job.

So our researchers came to the rescue. They developed a *special* glass and called it (for obvious reasons) "Front Glass Blue." Lenses made of this glass produced just the right shade. And along with the red, green and yellow lenses, they were *heat-resistant*, too.

Each lens used in this colorful spectacle measures 18 inches in diameter and weighs almost 7 pounds. All 686 were pressed from *standard* molds, delivered in record time.

O.K., you're not interested in color. Still there might be some glass or glass product that can be of help to you. Good introduction to the fascinating world of glass technology is the booklet, "This Is Glass." In its 64 pages you'll find facts and pictures that might give you some ideas. Remember: Corning can do almost anything with glass.

Corning means research in Glass

CORNING GLASS WORKS, 50-8 Crystal Street, Corning, New York

Please send me: B-91, "VYCOR brand industrial glassware by Corning" ☐ B-83, "Properties of Selected Commercial Glasses" ☐ IZ-1, "Designing With Glass for Industrial, Commercial and Consumer Applications" ☐ "This Is Glass" ☐.

Name..Title....................

Company..

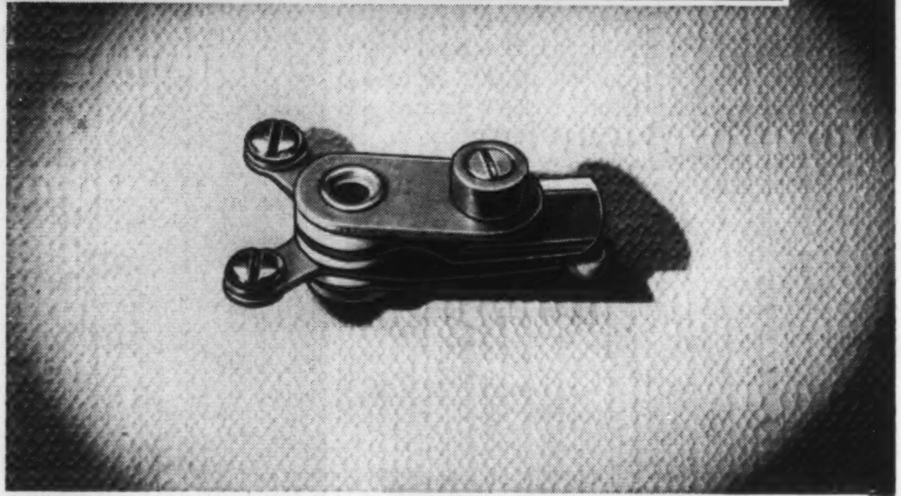
Street..

City..Zone..........State....................

For more information, turn to Reader Service card, circle No. 502

CHACE

THERMOSTATIC BIMETAL
ACTUATES ANOTHER PRECISION PRODUCT



A PRODUCT OF NORWALK THERMOSTAT COMPANY, NORWALK, OHIO

THE NorStat THERMOSTAT

NorStat Type A Thermostats (non-adjustable shown) provide make and break control of electrical circuits in appliances, heating and ventilating equipment, business machines, vending devices, manufacturing machinery and accessories. Which makes it quite likely you've unwittingly depended upon this hidden control in a percolator, beverage vendor, solder pot, furnace, sterilizer — or scores of other temperature actuated devices. The operating range is from 0° F. to 650° F. Accuracy is assured by NorStat's lubricated adjusting system insulator which rides on a raised dimple in the lower spring blade — and, of course, by the reliable actuating element of Chace Thermostatic Bimetal.

In order to produce a large volume of sensitive controls such as the NorStat Thermostat and *know* that the devices will continue to function without attention, the manufacturer must select his source of bimetal with care. He must be assured that the actuating element is of *the* alloys most suitable for his purpose, that tolerances are maintained always, that manufacturing processes and equipment are such as produce top quality, that the price is fair — quality considered — and that the integrity of the source is beyond question. Our more than a third of a century devoted exclusively to the development and production of precision thermostatic bimetal is his assurance of our qualifications to satisfy the most demanding.

So remember Chace when you, too, design for protection of life, valuable equipment, or for temperature actuation or indication. Dependable Chace Thermostatic Bimetal is available in over 30 types, in strip, coil or completely fabricated and assembled elements to your design. Send for our new 1958 booklet, "Successful Applications for Chace Thermostatic Bimetal," containing many pages of design data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service card, circle No. 423

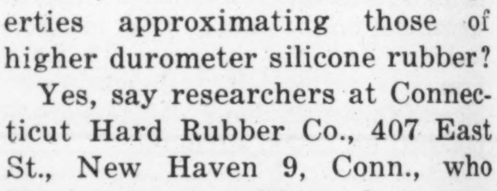
and second coatings and cuts the cost of finishing doors, furniture parts, cabinets, house trailer and boat parts, and other wood products by at least 75%.

Since stain can be introduced into the wood surface during the process, a final finish can be attained without further application of paints or varnishes. Otherwise, the machine-made surface, which costs about ½¢ per sq ft, serves as a base for a single coat of paint, oil stain or varnish.

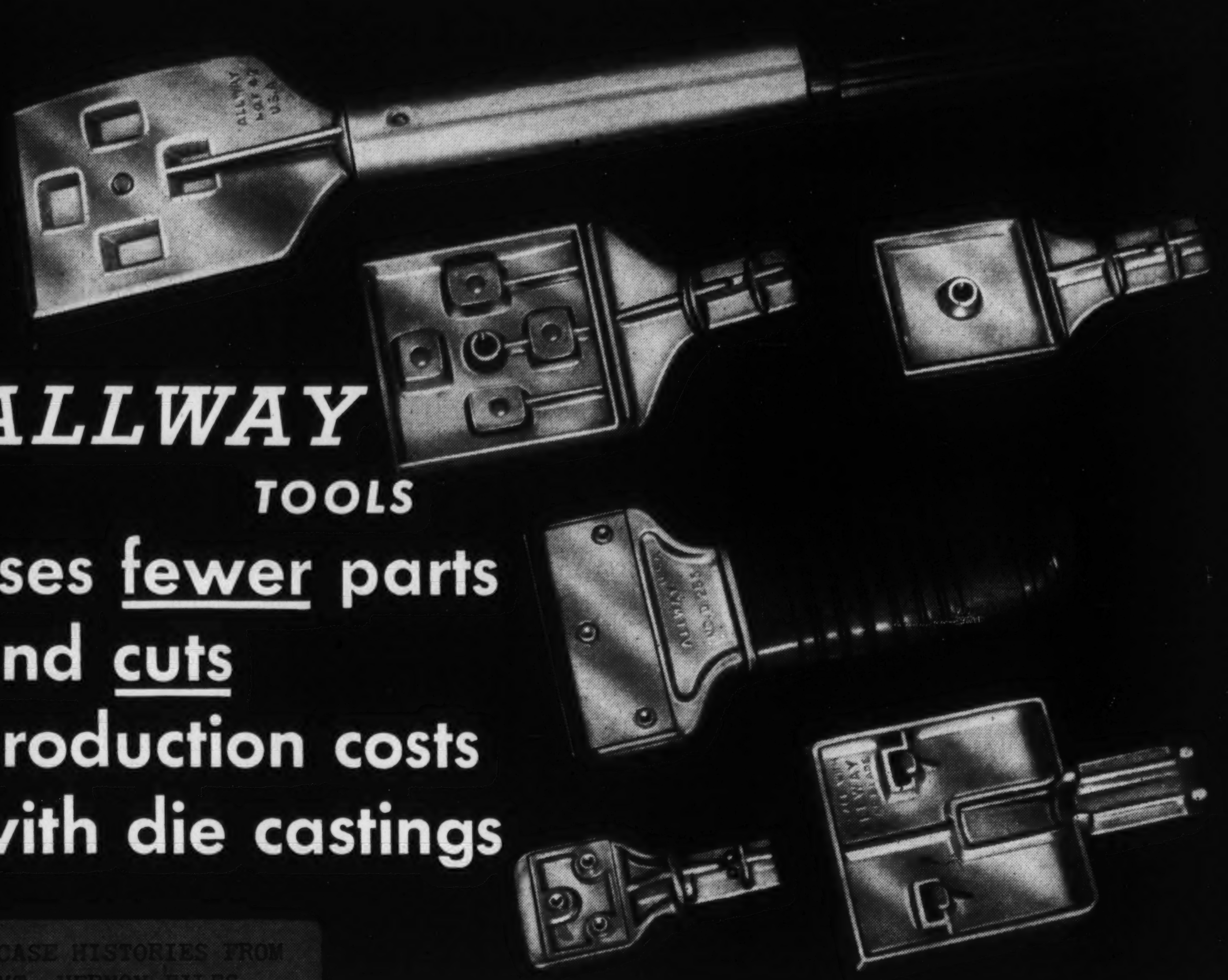
Soft Silicone Rubber Has High Strength

Can a low durometer silicone rubber have compression-deflection characteristics approximating those of firm sponge, yet have tensile, tear and elongation properties approximating those of higher durometer silicone rubber?

Yes, say researchers at Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn., who have come up with such a compound. The researchers say their compound, having a Shore Duromoter A hardness of 25 ±5, has 30% compression set after aging 70 hr at 300 F. The compound, designated M-717, has a tensile strength of 800-1000 psi, an elongation of 600-800%, and a tear strength of 120 lb per in. at room temperature. A commercial 50 durometer silicone rubber compound has a tensile strength of 800-1000 psi, an elongation of 200-300%, and a tear strength of



Low compression set *is the feature of a new low durometer silicone rubber compound.*



ALLWAY TOOLS uses fewer parts and cuts production costs with die castings

CASE HISTORIES FROM
MT. VERNON FILES

"We set out to make the best looking—best performing—best priced line of woodscrapers on the market. Die casting helped us do it", reports Mr. Gringer, President, *Allway Tools.

There's no doubt about it—Allway 4 Edge Wood Scrapers for fine and rough work, and Allway Finishing Scrapers for fine work are easily one of the best designed and easiest performing scrapers available. And a vital factor in their design and manufacture has been the full use of all the inherent advantages of zinc die casting.

Each blade mount is a light-weight, rigid, ribbed casting of great strength. Allway Scrapers have to withstand lots of hard pressure without bending or cracking.

All design requirements, mounting bosses, correct curvature for effective blade angle, clean edges and finish, high production rate, were economically achieved. In addition to their quality design and construction, Allway Scrapers have to be competitively priced.

Allway takes the zinc die castings as they come in – drills and taps a hole or swages a rivet stud as required in each model – firmly stakes a steel handle to it – adds blade and vinyl grip, and the scraper is ready for market. Result – simplified, fast, low-cost production and a superior product.

When you are confronted with problems of lower production costs or product improvement, consider die casting and bring your problem to us. Our complete four-fold service will help provide the answers. Contact your nearest Mt. Vernon sales representative for quick action.

*Allway Manufacturing Co., N. Y. C.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

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LUTHERVILLE, MD.: Mr. C. McIntosh Gordon, Mays Chapel Rd.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
BROOKLYN, N. Y.: Robert V. Moore, 2317 Plumb 2nd St.
EAST ORANGE, N. J.: Mr. George E. Hahl, 39 So. Munn Ave.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115
BOSTON, MASS.: Mr. James Cleary, 61 Exeter Street

For more information, turn to Reader Service card, circle No. 493

"Continue to use Morganite!"

TYPICAL TEST REPORT SHOWS MORGANITE OUTLASTS OTHER MOLD MATERIALS 7 TO 1!

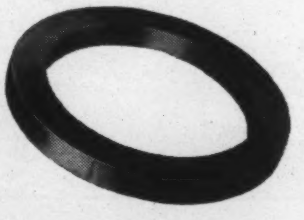
No. 714A

"During the past 12 months, 1050 regular molds were used on the large jobs at considerable cost. These molds had an average life of 2½ hrs. on the machines for a total of 2625 hours. In the same number of hours, only 175 Morganite molds (average life 15 hours) are needed at a fraction of the cost. Substantial savings in less down time also realized. Due to mold changes, when using Morganite, another savings would be realized by saving ware now lost during such changes.

Morganite ordered for use on all future runs."

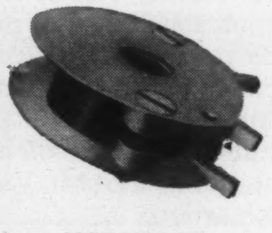
Signed (Name on request)
Chief Test Engineer

CAM THRUST BEARING



SELF LUBRICATING PISTON RING

JET ENGINE PUMP VANE



MORGANITE CURRENT COLLECTOR

Bearings
Pump Vanes
Valves
Slides
Seal Noses
Gland Rings
Rod Packings
Piston Rings
Electro-Mechanical Contacts

Specify SELF-LUBRICATING MORGANITE

Production engineers and product designers! Morganite offers many important advantages ... is self-lubricating, non-contaminating, corrosion resistant, non-warping, and non-gumming. Get all the facts on cost-saving, high-performance Morganite components now.

Call or write for complete information—no obligation.

Morganite INCORPORATED ... FOR OVER HALF A CENTURY

3324 48th Avenue
Long Island City 1, N. Y.

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts. Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

For more information, turn to Reader Service Card, circle No. 412

65 lb per in. at room temperature.

Anticipated uses for M-717 include various sealing applications. The company is making the compound available as made-to-order sheets, moldings and extrusions.

Other News . . .

Ferrous metals

▶ Three improved die steels—a carbon steel, a 5% chromium steel and a pre-hardened 5% chromium steel—are available from Latrobe Steel Co., Latrobe, Pa.

▶ Better aluminum-coated steel wire for electrical devices has come out of the development of a new process that applies thick aluminum coatings to the wire. The coated wire, called Alumoweld, is in limited production at Copperweld Steel Co., Warren, Ohio. The coating process was developed at Battelle Memorial Institute, Columbus, Ohio.

Nonferrous metals

▶ Germanium crystals, manufactured to specifications from 0.1 to 30 ohm-cm (N or P type), are now available from Semimetals, Inc., 133-20 91st Ave., Richmond Hill 18, N. Y. Price of the single crystal germanium is \$800 to \$1200 per kg.

▶ Cold drawn nickel wire and rod in sizes from ½ to 0.002 in. in dia and in widths up to 6 in. are obtainable from Techalloy Co., Inc., Rahns, Pa. The nickel wire and rod are made of special heat resisting alloys developed by the International Nickel Co.

Plastics and rubber

▶ A flame retardant fiberglass-polyester laminate for electrical insulation has been introduced by Glastic Corp., 4321 Glenridge Rd., Cleveland 21. The company says the laminate costs far less than specialty grades previously required to meet flame retardance requirements.

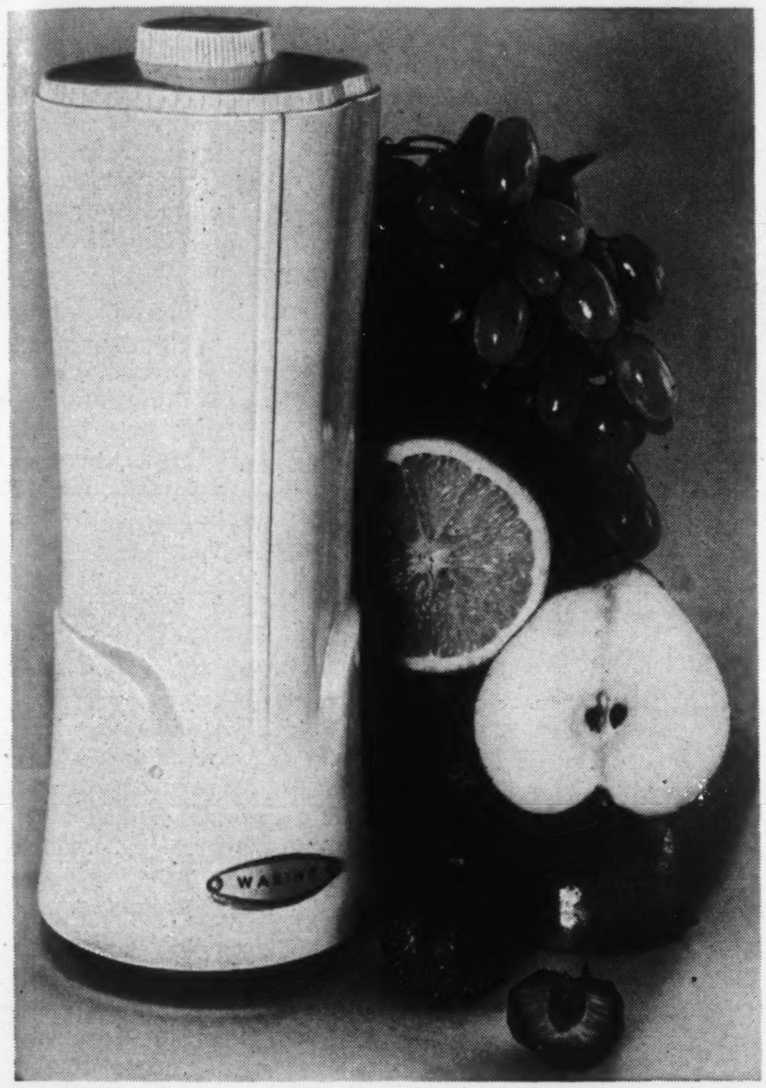
▶ Machinable stock of diallyl phthalate can be obtained in a wide variety of shapes and sizes from Mesa Plastics Co., 11751 Mississippi Ave., Los Angeles 25. The company guarantees the stock to be free of voids, cracks and porosities to insure complete machinability to any configuration.

(continued on p 168)

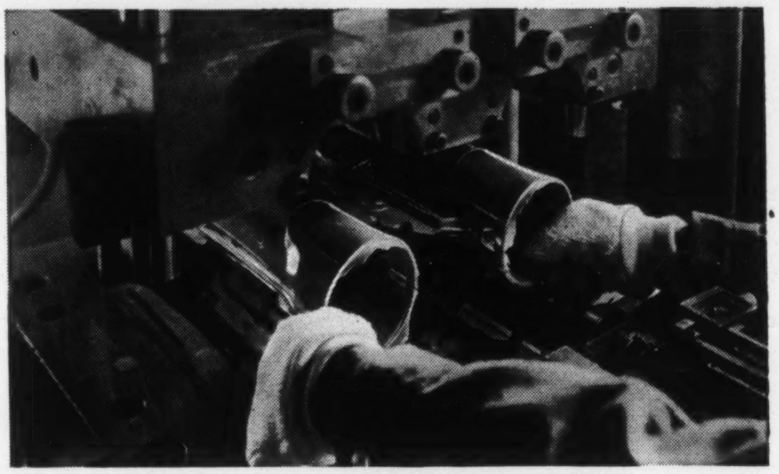
CYANAMID

PLASTICS IN ELECTRICAL DESIGN

Drink Mixer and Server...One Graceful Molding of CYMEL®



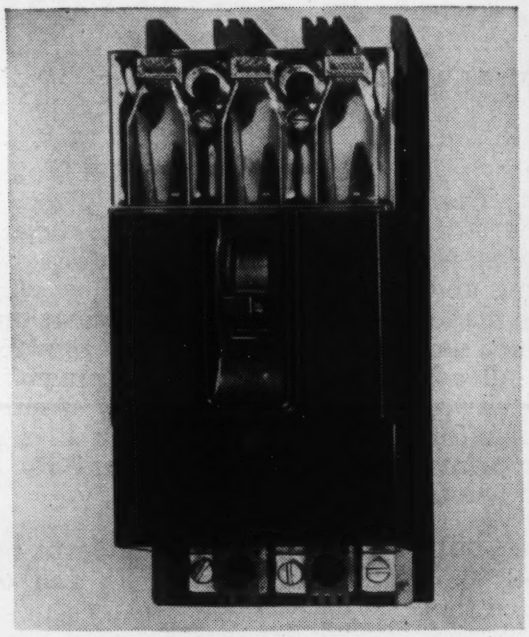
Conceived as both mixer and server of beverages and sauces, the new Waring Drink Mixer serves graciously anywhere in the home. In accord with the need for style, portability and economy, the mixing cavity, motor housing, handle and pouring spout are molded in one unit of CYMEL 1077 melamine molding compound—familiar to consumers in popular MELMAC® dinnerware. This styling in CYMEL keeps down size, weight, and cost. CYMEL provides insulation, strength, resistance to heat and staining, excellent stability, low moisture absorption, permanent rich molded-in color and hard surface.

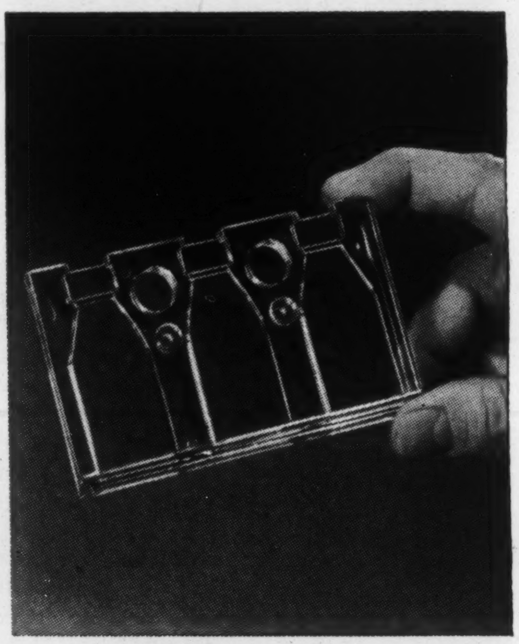


Two complete one-piece mixer bodies are molded of CYMEL in each cycle. Mixing cavities and motor housings are formed by cores. Here, mold is open, motor housing cores have been automatically retracted, and the two mixers are being manually removed from top-cavity cores. Molder is Shaw Insulator Company.

CYMAC® Window on Circuit Breaker Contacts

A removable transparent cover through which contacts are clearly visible is the outstanding feature of a new circuit breaker recently introduced by Standard Control Division of Westinghouse Electric Company. The cover of the Saf-T-Vue circuit breaker, which reveals at a glance whether contacts are open or closed, is molded of CYMAC 201 methylstyrene acrylonitrile copolymer, which provides necessary transparency, heat and break resistance, and surface hardness at comparatively low cost.





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Plastics
and Resins
Division

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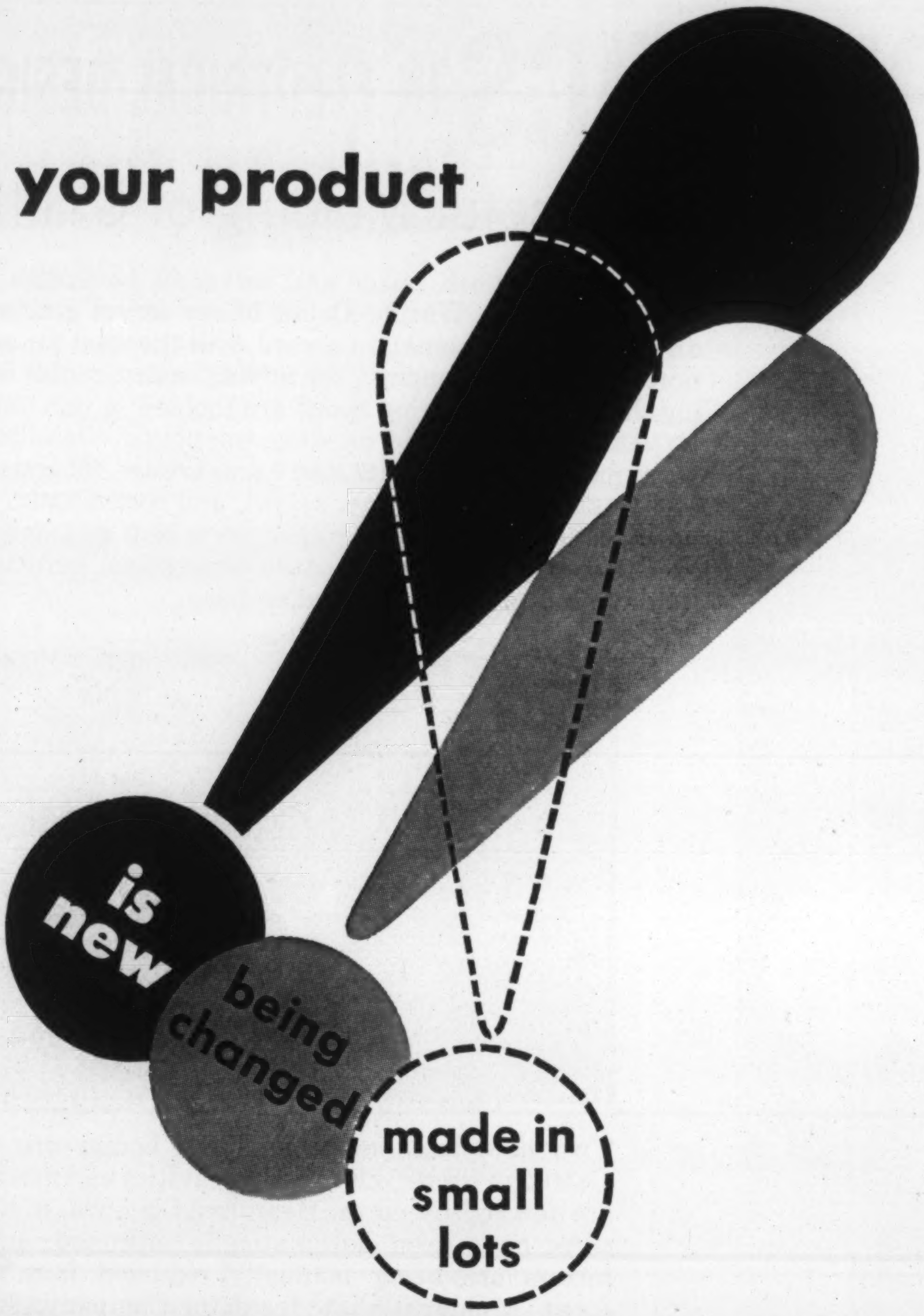
PLASTICS AND RESINS DIVISION
32 Rockefeller Plaza, New York 20, N. Y.

In Canada: Cyanamid of Canada Limited, Montreal and Toronto
Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • New York • Oakland • Philadelphia • St. Louis • Seattle

For more information, turn to Reader Service card, circle No. 504

if your product



Federal Short Run Stampings may be your answer

Consider these advantages Federal "Controlled Tolerance" Short Run Stampings can give you. First, a *savings* of up to 80% of the cost of conventional tooling methods. Second, *quicker delivery* due to our special methods of tooling and manufacturing. Third, *quality* component parts made exactly to your specifications by skilled craftsmen using modern methods on modern machines. They all add up to quality stampings in any quantity from two pieces to 10,000 of any stampable material up to 10" x 14" in size and up to 3/8" thick. Send your print or part to nearest plant for a Federal Analyzed Quotation.

Write for free Catalog 201. Tells how to reduce costs by using short run stampings . . . full of design tips.

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FEDERAL STAMPING COMPANY
7307 Atoll Ave., No. Hollywood, Calif.

For more information, turn to Reader Service card, circle No. 372

What's new IN MATERIALS

Other nonmetallics

▶ Vacuum metallized paper has been developed by Vaculite Corp., 70 Memorial Dr., Cambridge 42, Mass. The material is a highly reflectant metallic-coated sheet having the appearance of polished aluminum but able to be processed like paper in all converting equipment.

▶ An ethylenic resin-coated fabric called Armalon has been developed by E. I. du Pont de Nemours & Co., Inc., Fabrics Div., Wilmington 98, Del. The coated fabric, said to remain pliable at both high and low temperatures, has potential use as camera bellows, dark room curtaining and drawing board covers.

Finishes

▶ A clear coating called Irilac 1000 has been developed by Allied Research Products, Inc., 4004-06 E. Monument St., Baltimore 5. The coating is said to provide protection against corrosion, fingerprinting and abrasion on base metals and electrochemically and chemically finished surfaces without changing the appearance of the metallic surface.

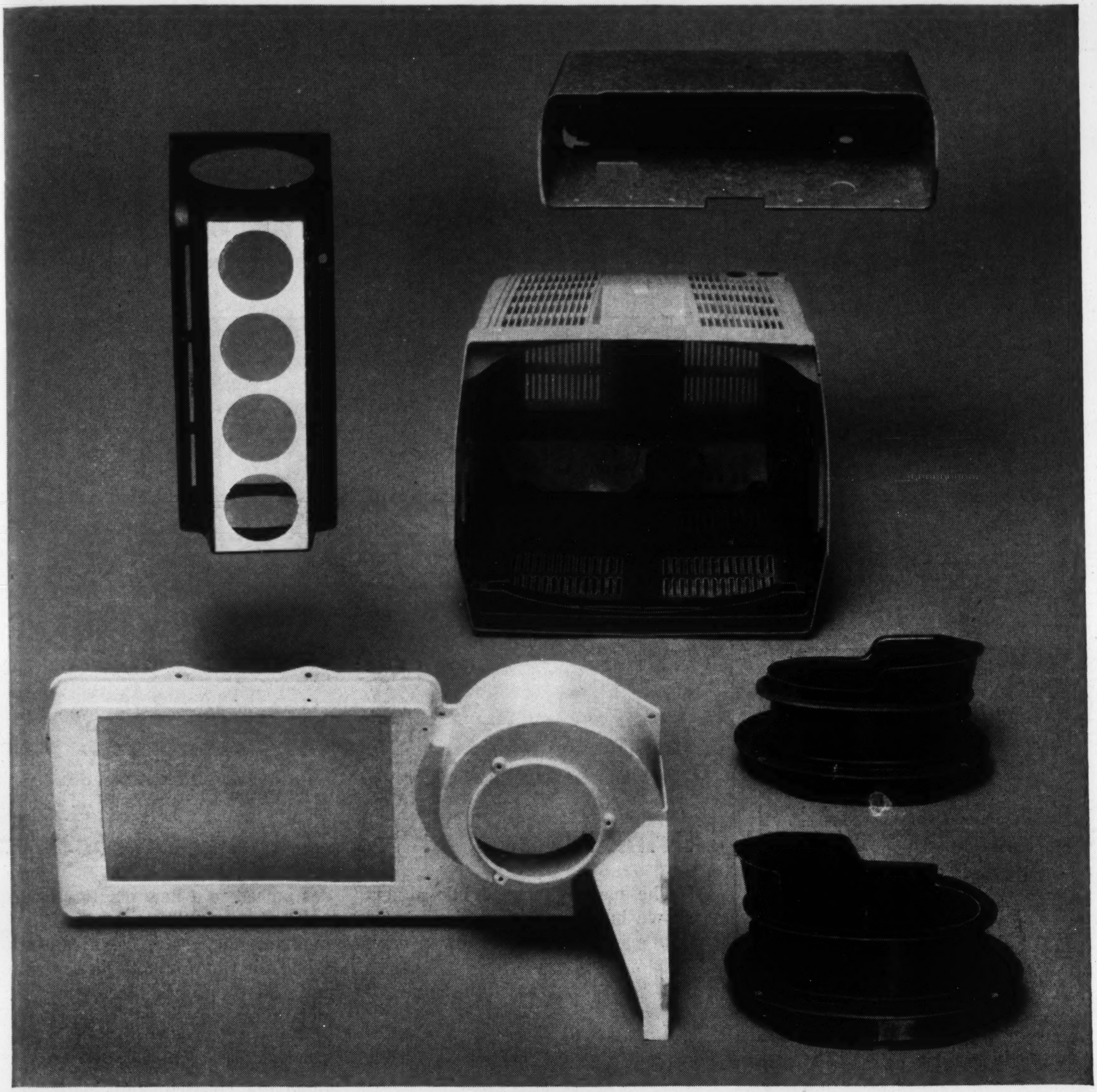
▶ An organic coating for household appliances, known as Dynakote, has been developed by Canadian Industries Ltd., P. O. Box 10, Montreal, Canada. Based on a cross linked vinyl copolymer, the coating is not attacked by acids from citrus fruits or sour milk and has good resistance to alkaline solutions.

Joining materials

▶ A self-sealing threaded fastener called Uniseal is available from Uniseal Co. of Calif., 8021 S. Western Ave., Los Angeles 47. Designed for commercial and military aircraft, the fastener contains a thin shim of Teflon set in a specially designed groove.

▶ An adhesive for bonding scrap polyurethane foam to form new sheets or molded articles has been developed by Java Latex & Chemical Corp., 1713 West Farms Rd., New York 60. The adhesive, Javabond, is said to withstand dry cleaning and washing after it has been cured.

▶ NVD is the name given to Du Pont's improved adhesive for bonding vinyl compounds to fabrics of nylon and Dacron polyester fiber. The improved material has high bond strength and good shelf life. The adhesive is currently available as a partially formulated compound from B. B. Chemical Co., Cambridge, Mass.



Wide range of premix moldings by the Plastics Division of General American Transportation Corporation includes: automotive air conditioning cabinet for O. A. Sutton Corp., Inc.; Silvertone portable TV cabinet for Sears, Roebuck and Co.; air duct and glove compartment for a leading automobile manufacturer; vending machine air duct for Vendo Co.

Premix moldings give you all three... quality, economy, versatility

Like to market better products and cut costs at the same time? Then premix moldings are for you!

When resins and reinforcing fibers are blended beforehand, more complex molds are not only possible but completely practical. Slots, grooves, holes, bosses and parts with varying wall thicknesses can be formed right in the mold. And whether the part is simple or complex, you'll get moldings with uniform strength and wall thicknesses. Premix moldings are improving products and cutting costs for a wide variety of industries using strong, rigid, reinforced plastics.

Molders across the nation rely on Dow Vinyltoluene and Dow Styrene for top-quality premix moldings. They can help you to better products at lower costs. For the names of molders and suppliers, contact your nearest Dow Sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Dept. 2206G-1.

YOU CAN DEPEND ON DOW

For more information, turn to Reader Service card, circle No. 363

NOW, hopper-fed headless set screws AUTOMATE SUB ASSEMBLY!

CUT Operational Time 80% to 90%
CUT Floor Area
CUT Floor Waste from 30% to 0
CUT Worker Fatigue

The new Setko System can be used for almost any headless set screw application in sub or final assembly. All type points and most popular styles of set screws can be hopper fed.

This is what users have to say about Setko Hopper Feeding . . .

"Increased insertion rate of 1/4-20, x 1/2 socket head set screw in shaft lock collar from 1200 a day by manual insertion to 2400 a day."

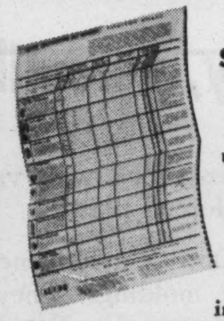
"Set Screw insertion in rotor was increased from 5600 to 9600 in an eight hour day. We get better quality insertions."

"Reduced rejects to almost zero. Increased insertion rates from 2000 to 4800 . . . Almost triple."

HEXAGON AND FLUTED SOCKET SET SCREWS
SLOTTED SET SCREWS
SLABBED SET SCREWS

LICK RECESSION COST PROBLEMS WITH SETKO.

SEND FOR NEW *FREE* SELECTOR CHART of Self-Locking Set Screws.



Shows how and where to use over 1,001 combinations for particular applications.

Write today for your copy and full information . . .

Use your letterhead or write your name and address in the margin of this page . . . Tear out and mail.

Pat. No 2,638,945
Other Patents Pending

Set Screw & Mfg. Co.
149 Main Street, Bartlett, Ill.

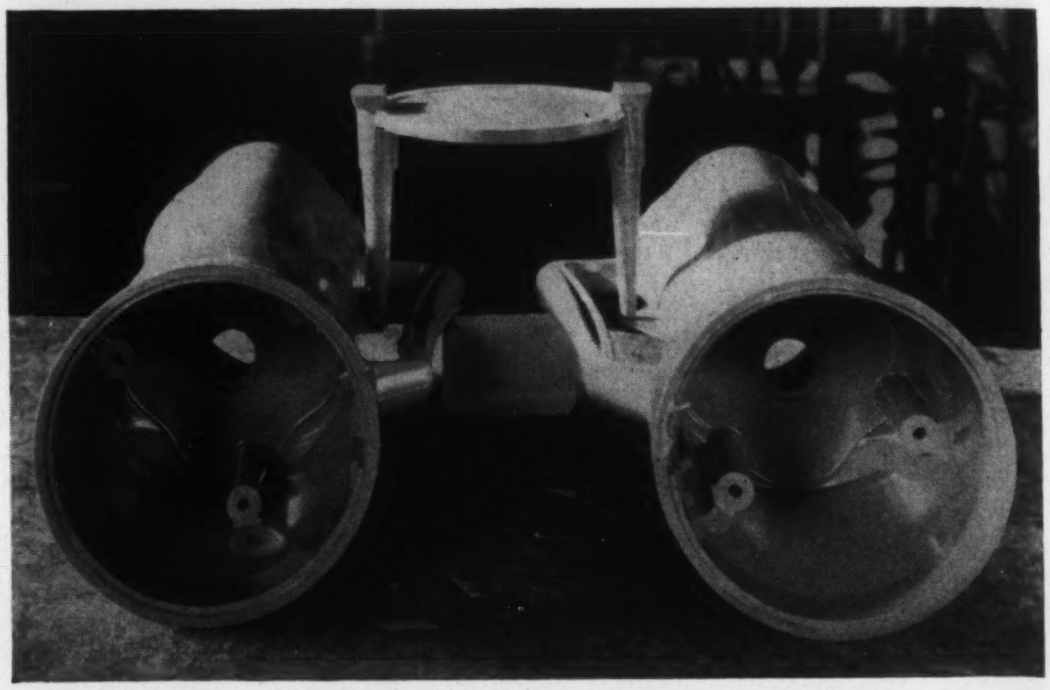
1587RR

For more information, circle No. 511

Missile—cont'd from p 12

The missile itself is powered by liquid-fueled (oxygen and hydrocarbons) rocket engines and is designed to carry a thermonuclear warhead 5500 nautical miles.

The airframe is manufactured and the entire missile assembled by Convair (Astronautics) Div., General Dynamics Corp.



Complex molding *is done in one operation using a new technique.*

Drink Mixer Uses New Molding Method

■ The new Waring drink mixer shown in the accompanying photo is a good example of how a new design led to a new plastics molding technique. According to Shaw Insulator Co., design requirements called for the mixer to be portable and have a one-piece, molded melamine body consisting of integral mixing cavity, motor housing, handle, pouring spout, motor mounting bosses and plug receptacle opening.

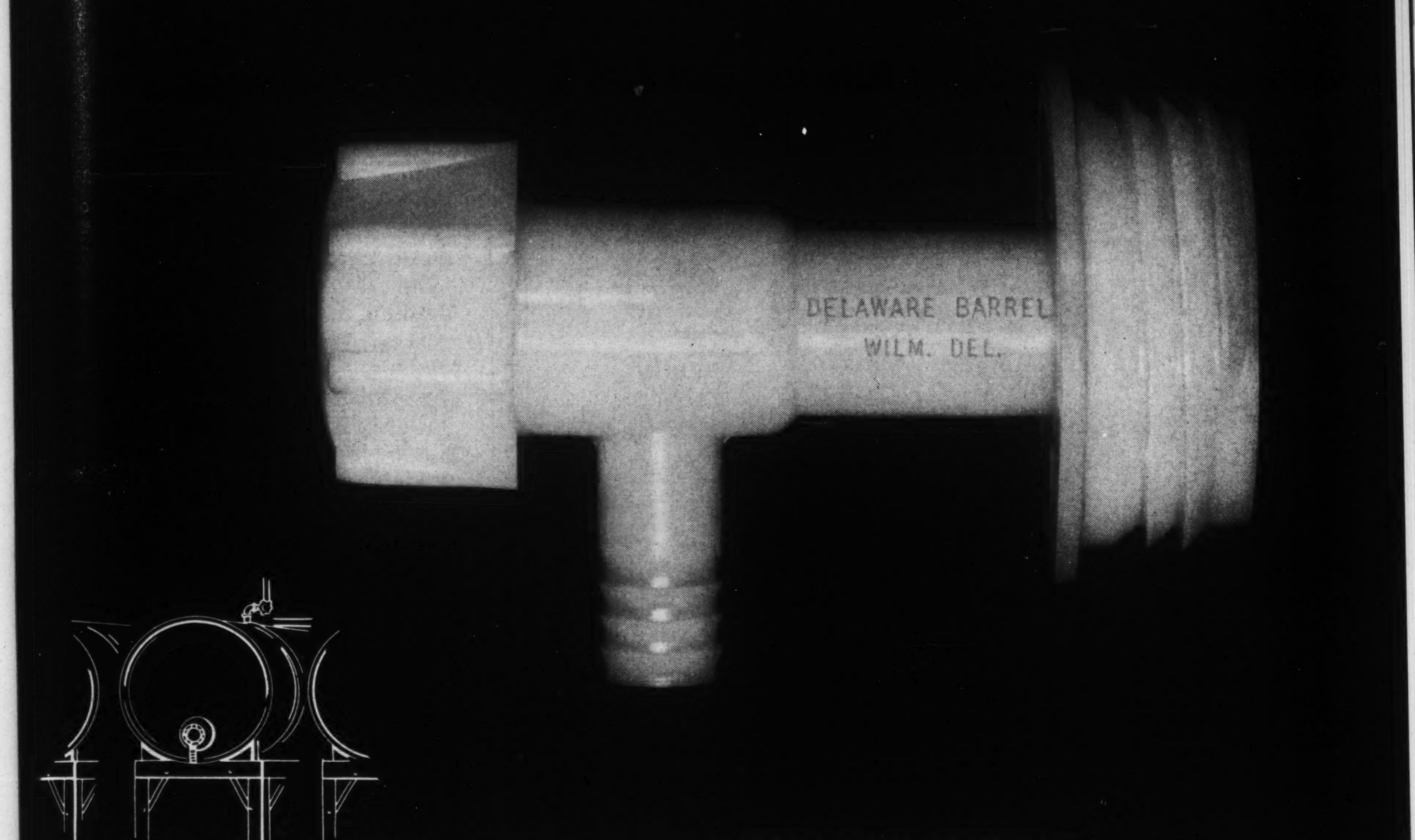
Melamine drink mixer.

Melamine was selected for its heat and break resistance and mechanical stability. However, the job turned out to be too difficult for conventional transfer molding techniques.

The new technique, developed by Shaw and called the "3-plate plunger transfer mold," solved the problem. It employs a floating plate through which the material runs to the various mold cavities in a downward flow rather than a lateral flow along the mold-parting line. As a result, several advantages are achieved: 1) closer grouping of cavities; 2) direct

For more information, circle No. 460 ➤

DESIGNED IN CELANESE FORTIFLEX...



DRUM VALVE ASSEMBLY

MOLDED IN FORTIFLEX BY DELAWARE BARREL & DRUM CO., INC., WILMINGTON, DEL.

New Delaware drum valve is a Fortiflex-inspired design improvement

When corrosive materials come in steel or plastic drums, this is the spigot to thread into the bung hole! The valve—molded in one part—is made entirely of Fortiflex . . . resistant to acids and alkalis, heat and cold, with economical molded-in threads. Result: longer, trouble-free, dependable, corrosion proof service life.

Fortiflex is presently available in four melt indexes developed to accommodate a wide range of conditions and applications of interest to designers and manufacturers. For more information and/or test quantities, use the coupon.

Celanese® Fortiflex®

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N. Y. 16

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

			FORTIFLEX RESINS			
PHYSICAL PROPERTIES	ASTM METHOD	UNITS	A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	$N^{25}D$	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (⅛" specimen, 24 hrs. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0

Celanese Corporation of America, Plastics Division,
Dept. 102-H, 744 Broad Street, Newark 2, N. J.

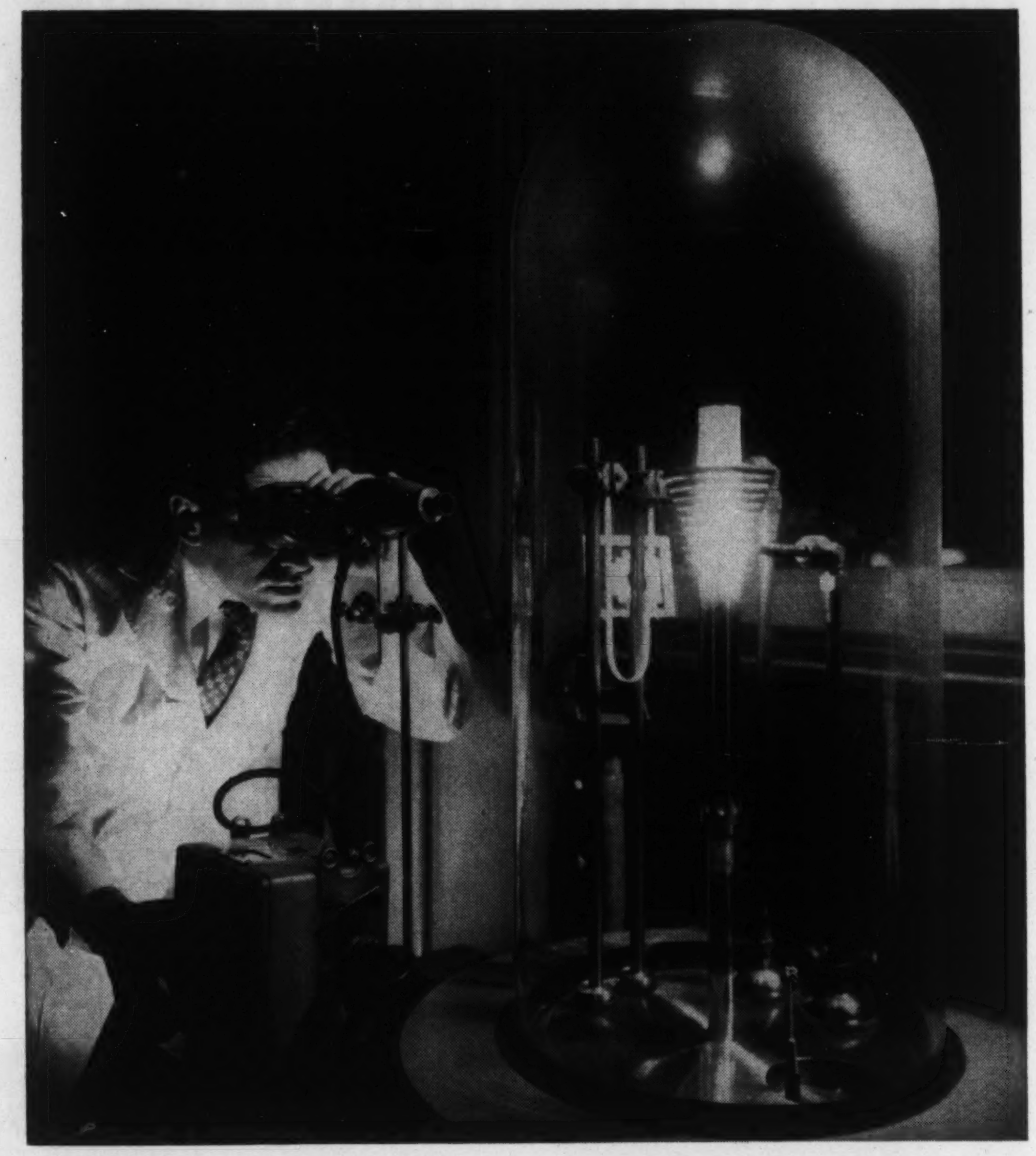
Please send: ☐ more information on, ☐ test quantities of Fortiflex.

Name__________ Title__________

Company__________

Address__________

City__________ State__________



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Here, at the Westinghouse Metals Plant, industry can develop, create or improve metals and methods without heavy capital investment. Complete modern facilities for melting, forging, conditioning, heat treating, hot and cold rolling, precision casting and powder metal molding are coupled with the latest metalworking equipment. Westinghouse can help you proceed from the raw material to your finished part or product.

Use the Westinghouse Metals Plant. This combination development and pilot-plant facility provides the place where your new metal ideas can be scaled under proved production conditions.

Write today for booklet B-6570, describing this new concept in metals development. Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pa. J-05009

**Panel at right shows a few outstanding metals developed by Westinghouse.*

W-545
NICROTUNG
HIPERNIK
CONPERNIK
HIPERCO
KOVAR
DISCALOY

YOU CAN BE SURE...IF IT'S Westinghouse

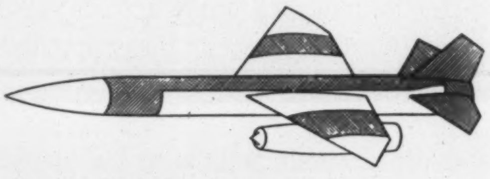
For more information, turn to Reader Service card, circle No. 414

flow through the runners from loading well to the gate; 3) greater flexibility in choice of gate location; and 4) size of the loading well need be no larger than is necessary for efficient loading.

According to Shaw, the new technique was the only method by which the mixer could be molded. However, the technique itself is applicable to a wide variety of difficult and complex transfer molding applications.

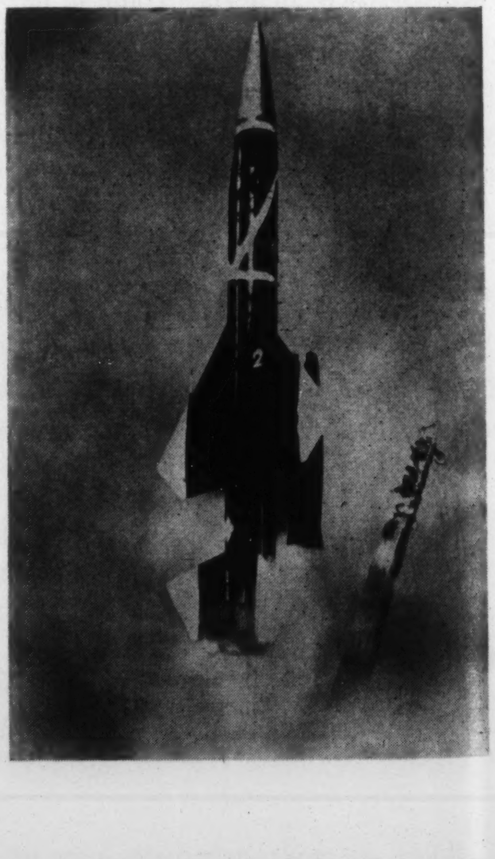
Magnesium-Thorium Used in Bomarc Missile

Light weight, stiffness and resistance to heat are the reasons given for the selection of magnesium-thorium alloys for the Air Force's Bomarc interceptor missile. The missile, built by Boeing



***Cross-hatched area** shows extensive use of magnesium-thorium sheet in . . .*

. . . Bomarc interceptor missile.



WHO BUYS DIE CASTINGS?

These Industries Do!

Last year, die casting accounted for the largest single use of zinc — displacing galvanizing for the first time in history as the metal's major consumer.

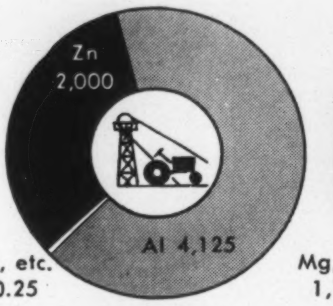
Consumption of zinc for die casting in 1957 is estimated at 370,177 tons. This amounts to 40% of all slab zinc consumed last year. Shipments of zinc die castings by job shop, or custom producers represented some 61% of the zinc die casting metal consumption totals. The balance represents captive production by end product manufacturers.

Prior to 1928, the year Bunker Hill pioneered the production of "four-nines" metal, die casters would never have dreamed that their zinc-base products would become a vital factor in modern engineering processing. Least of all could they have foreseen that in a relatively short span of years their infant industry would outrank the galvanizing industry as the nation's largest consumer of zinc.

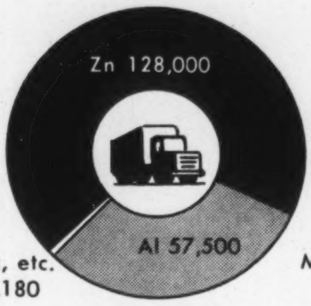
DIE CASTING
is the Process

ZINC,
the Metal

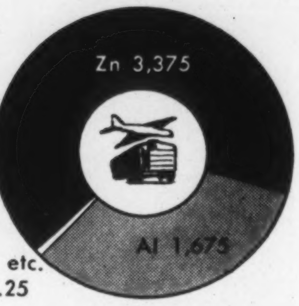
BUNKER HILL,
THE PREFERRED ZINC



Agricultural, Mining Construction Equipment

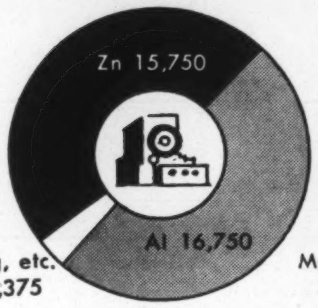


Automotive (Motor Vehicles)

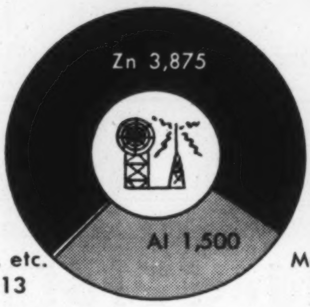


Other Transportation

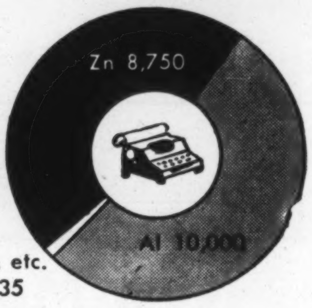
Commercial Industrial Machinery and Tools



Electronic Devices & Communication Equipment



Office Equipment & Business Machines

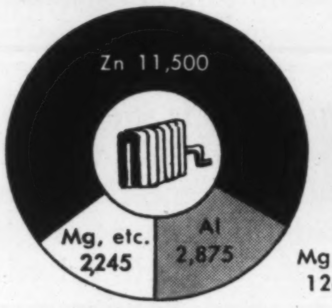


END USE DISTRIBUTION OF DIE CASTING SALES IN 1957
(By Metal, By Weight in Tons)

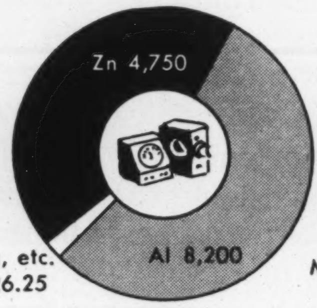
Totals represent all job shop sales. Captive use not included. Source: Reports of members to American Die Casting Institute.

Legend:

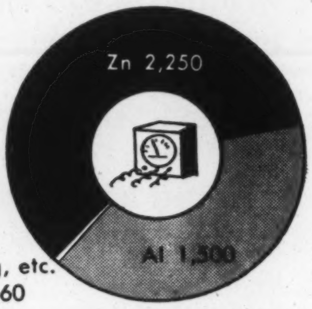
■ **Zinc** ▨ **Aluminum** □ **Magnesium & others**



Plumbing, Heating & Builders Hardware

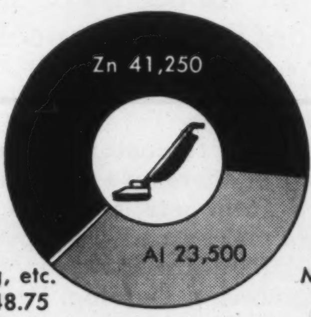


Photographic, Optical, Recording Devices, etc.

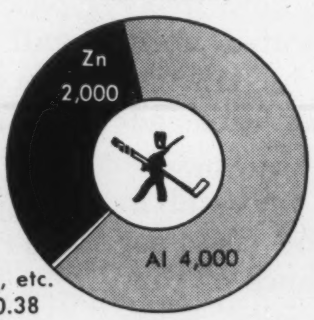


Timing & Time Operated Devices, Clocks

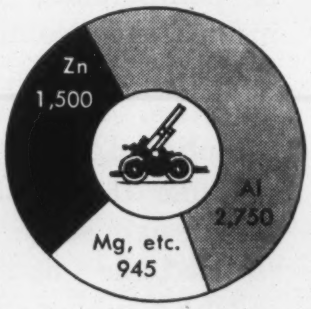
Home Appliances

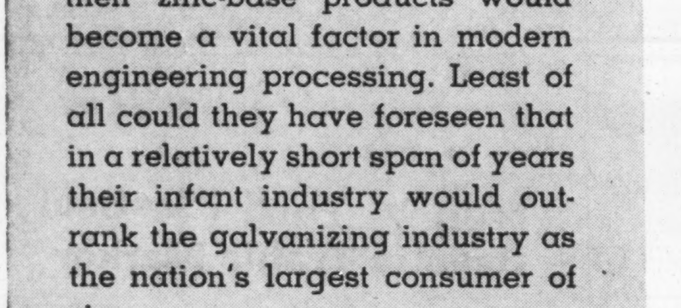


Toys, Sporting Goods, Personal Goods & Jewelry



National Defense





BUNKER HILL 99.99+% ZINC

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THE BUNKER HILL CO., 660 MARKET ST., SAN FRANCISCO, CALIF.

For more information, turn to Reader Service card, circle No. 494

Airplane Co., weighs only 7500 lb and makes extensive use of magnesium-thorium sheet, extrusions and castings.

The Bomarc project actually marks the first large-scale use of these alloys. The cross-hatched area in the accompanying sketch shows the extent to which the new material is being used. In the form of sheet, it is used for 46% of the upper and 32% of the lower wing surfaces; the entire upper and lower skins of the elevator stubs and doublers, fins and rudder doublers; the aft section of the body; the nose section skins; and the doors. In addition, magnesium-thorium extrusions are used for the leading and trailing edges of all control surfaces, and sand castings are used for certain parts of the airframe.

According to Dow Chemical Co., magnesium-thorium alloys in finished form are the least expensive of all airframe materials strong enough to perform at speeds of 1500 mph.

Molded Vinyl Plastisol Used in Traffic Marker

Lightweight traffic markers said to be strong enough to stand up under normal use, yet flexible enough to completely regain their original shape even after being crushed, are now being molded of vinyl plastisols.

According to Goodyear Tire & Rubber Co., the new hollow, cone-shaped markers are ideal for providing safety for utility crews, protecting newly painted traffic

USE THE 'SELECTOR'—You will find properties of most engineering materials, plus names and addresses of suppliers, in M/DE's *Materials Selector* reference issue, published last September.

SECTION D-D
A

Courtesy Scott Aviation Corp.

New Molded Profile Reveals Techniques for Better Rubber Specs

In the early stage of planning and design, it was questionable whether this face mask could be molded in rubber—in one piece—practically, yet economically . . . and here's why.

It calls for an ingeniously designed and machined mold to provide for facial contours, air inlets and outlets, undercuts, feathered edges, valve mounts, fastenings, etc.—one of the hardest-to-fill cavities ever encountered. Also, the rubber must be compounded to flow freely inside this complicated form and still maintain its knitting qualities. How was this accomplished?

While the mask was still in the design stage the customer realized the importance of consulting a rubber specialist. From this conference came an exchange of suggestions which led to a practical and functional design that permits molding these masks with unusual speed and economy. Here's the idea.

While a job is still on the drawing board consult with rubber specialists. Suggestions can often be made to eliminate high tooling costs or high priced compounds. End results give you better rubber parts, better performance and lowest cost. Regardless of how simple or complex your rubber needs may be call Continental—specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

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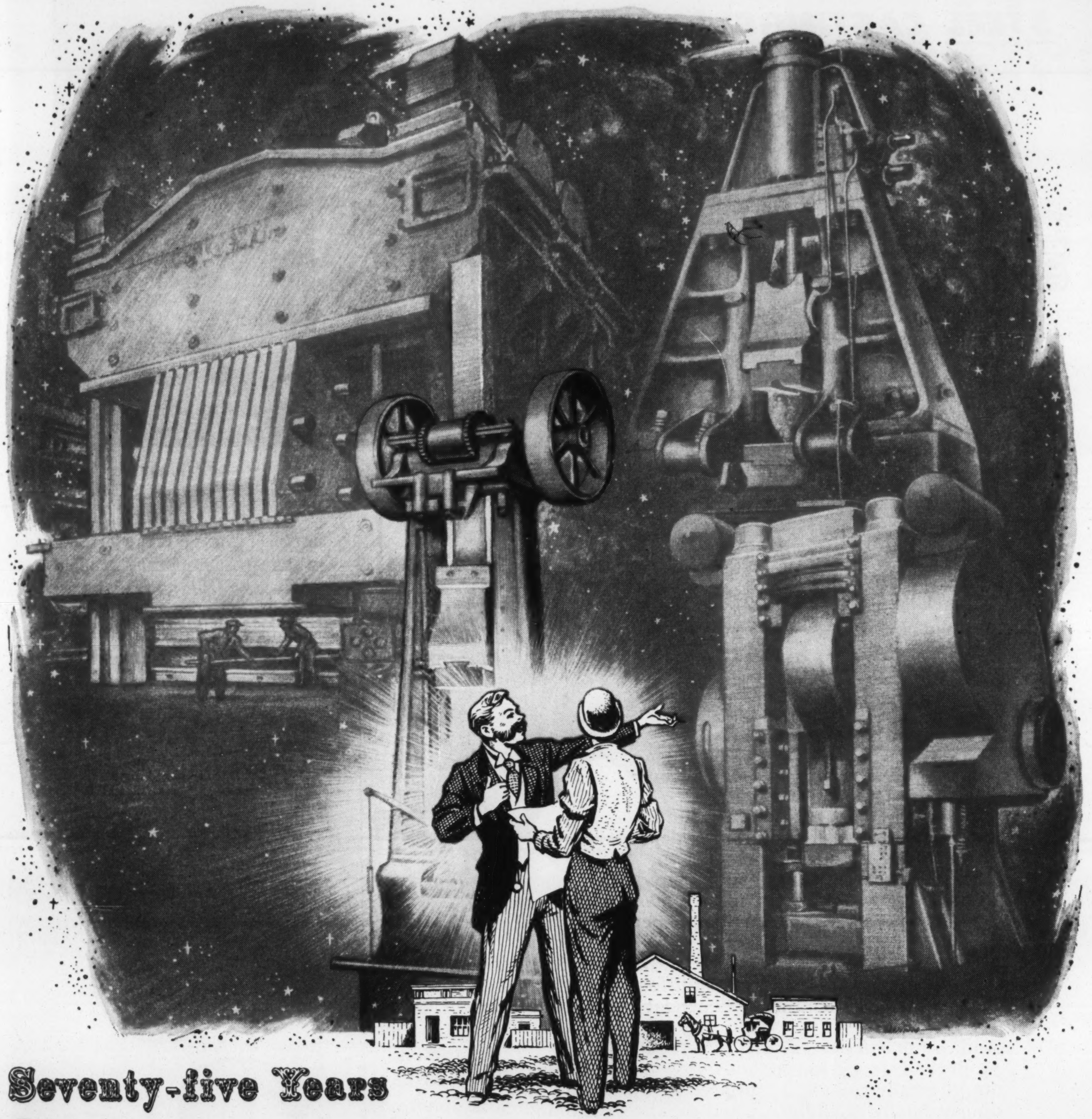


Seventy-five Years

THERE WAS a growing surplus in the United States Treasury—the Polygamy Act was passed—letter postage was reduced from three cents to two cents—the Brooklyn Bridge was opened—standard time was adopted—in 1883, when two young men, just graduated from Worcester Polytechnic Institute, established the business bearing their names—WYMAN-GORDON. The total capital was $27,000.

Integrity, initiative, ambition and ability were theirs. Endowed with these qualities and privileged to operate under that unique American system of free, private, competitive enterprise the Company prospered and grew.

On this our 75th anniversary, we salute the spirit of our founders and we pledge our every effort to help preserve, against the steady erosion of the last quarter century, that system which has made our nation what it is today and which has enabled us to build the greatest industrial production in the world, resulting in the highest standards for all segments of our people.

WYMAN-GORDON COMPANY

ESTABLISHED 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

HARVEY, ILLINOIS **WORCESTER 1, MASSACHUSETTS** DETROIT, MICHIGAN

For more information, turn to Reader Service card, circle No. 378

STEEL CASTINGS* help build dependability into the modern cargo carrier . . .

* . . Specifically **UNITCASTINGS!**

Transporting America's products by truck-trailer is a gigantic, ever-increasing task—calling for dependable, rugged, long-lasting equipment. This is the reason many manufacturers of over-the-highway carriers specify *foundry engineered UNITCASTINGS* for many component parts.

High quality cast steel affords intricate, one-piece designs . . . offers uniformity and strength for longer life, less maintenance, and more dependable product service.

And . . . *foundry engineered UNITCASTINGS*, produced by superior methods, assure steel castings that are internally sound . . . surfaces that are clean and dimensionally accurate . . . and require minimum finishing. Lower *finished* cost is the *real* advantage of specifying UNITCASTINGS. Write for complete information today!

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

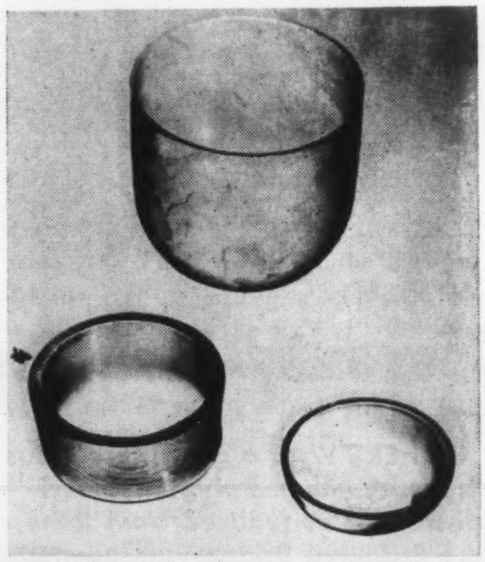
SPECIFICATION STEEL CASTINGS

For more information, turn to Reader Service card, circle No. 500

Cone-shaped vinyl *traffic markers can be lighted from within.*

stripes, and marking airport runways and temporary traffic lanes.

Because the markers are translucent, they can be lighted from within for nighttime use (see photo), and the tops of the cones are designed to accept adapters for holding flags, signals or blinker lights. The markers are not affected by grease, tar or dirt, and are easily cleaned.



Fused silica crucibles—The crucibles shown above are now being used for melting silicon, germanium and other semiconductors, where extremely careful control of purity is required. According to Corning Glass Works, the new crucibles are available in sizes up to 2½ in. in dia and 3 in. long, and can be used at temperatures up to 2600 F. (For information on other uses of fused silica see MATERIALS & METHODS, Feb '57, p 106.)

RARE EARTHS SERVE YOU EVERY DAY

A variety of common uses of these unique materials

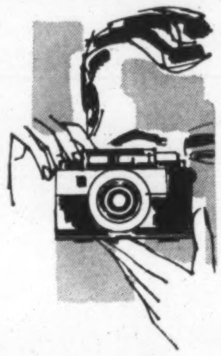
a report by LINDSAY

We've often suggested on this page that you might find interesting and profitable uses for the rare earths in your manufacturing processes. Here are some of the common but none-the-less exciting applications of rare earths.

Sharp News

FROM

Kodak



If you are a camera fan, you've probably heard about rare element glass developed by Eastman Kodak. It is called "rare" because it contains, among other things, lanthanum which is one of the rare earths.

Kodak utilized the principle that rare earth glass has a very high refractive index in relation to its dispersion. It, therefore, bends light more and spreads colors less. This permits production of lenses with shallower curves and, consequently, less inherent aberration. The result: higher quality lenses with fewer glass parts.

Rare element glass was perfected by Kodak for high precision military needs during World War II. The exciting part of the story is that Kodak's optical engineers have now found a way to produce rare earth element glass lenses in quantity at greatly reduced costs. That's why today you can get so fine a precision Kodak lens so economically.

Next time you get color slides with beautiful, needle-sharp images, shot with your favorite camera (Kodak, of course), you can thank the imaginative engineering of the people at Kodak . . . and think, too, of the amazing versatility of the rare earths.

IF YOU WEAR GLASSES

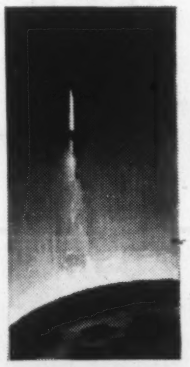
Chances are that your glasses were polished with ceria, a rare earth oxide preferred by many of the better optical firms. Cerium oxide is also widely used to polish high precision optical instruments, mirrors and other glass specialties. Speaking of versatility, certain of the rare earths are used to decolorize glass; others add the lovely, delicate colors so many people like in fine glassware.

HAVE A LIGHT

Top quality lighter flints are made of misch metal (an alloy of mixed rare earths). Rare earth metals are also used to create better alloy steels and magnesium alloys for high temperature service.

OUT OF THIS WORLD

Thorium, intimately associated with the rare earths, is literally out of this world – in the outer atmosphere! For thorium is an essential metal in the production of the alloy skin of the third stage of a rocket. Thorium has unique qualities which make it possible to produce a thorium-magnesium alloy which does not burn up at the fantastic speed of the rocket – up to 18,000 miles per hour.



AND A FEW MORE

More perhaps than you have suspected, *you* enjoy *every day* the benefit of the truly remarkable qualities of rare earths. They are used in the production of such widely diversified daily essentials (to name only a few) as movie projectors, textiles, ceramics, paint, TV picture tubes, petroleum, chrome plating, electrical resistance alloys, pharmaceuticals, ink, X-ray machines. Does all this give you an idea you can explore in your business?

THIS IS THE "COMMERCIAL"

As the TV announcer says, we pause for a brief announcement. If you are thinking about the possibility of using rare earths, even in the high purities, don't worry about availabilities. Most of them are available for prompt shipment in quantities of an ounce to a carload. How much do you need? Even more important, prices have been sharply reduced during recent years. You'll find the rare earths economically practical . . . and wonderfully useful.

So here's ample evidence that rare earths touch you in some way virtually every day. Certainly they are worth your own critical investigation. What helpful information would you like from us – today?

PLEASE ADDRESS INQUIRIES TO

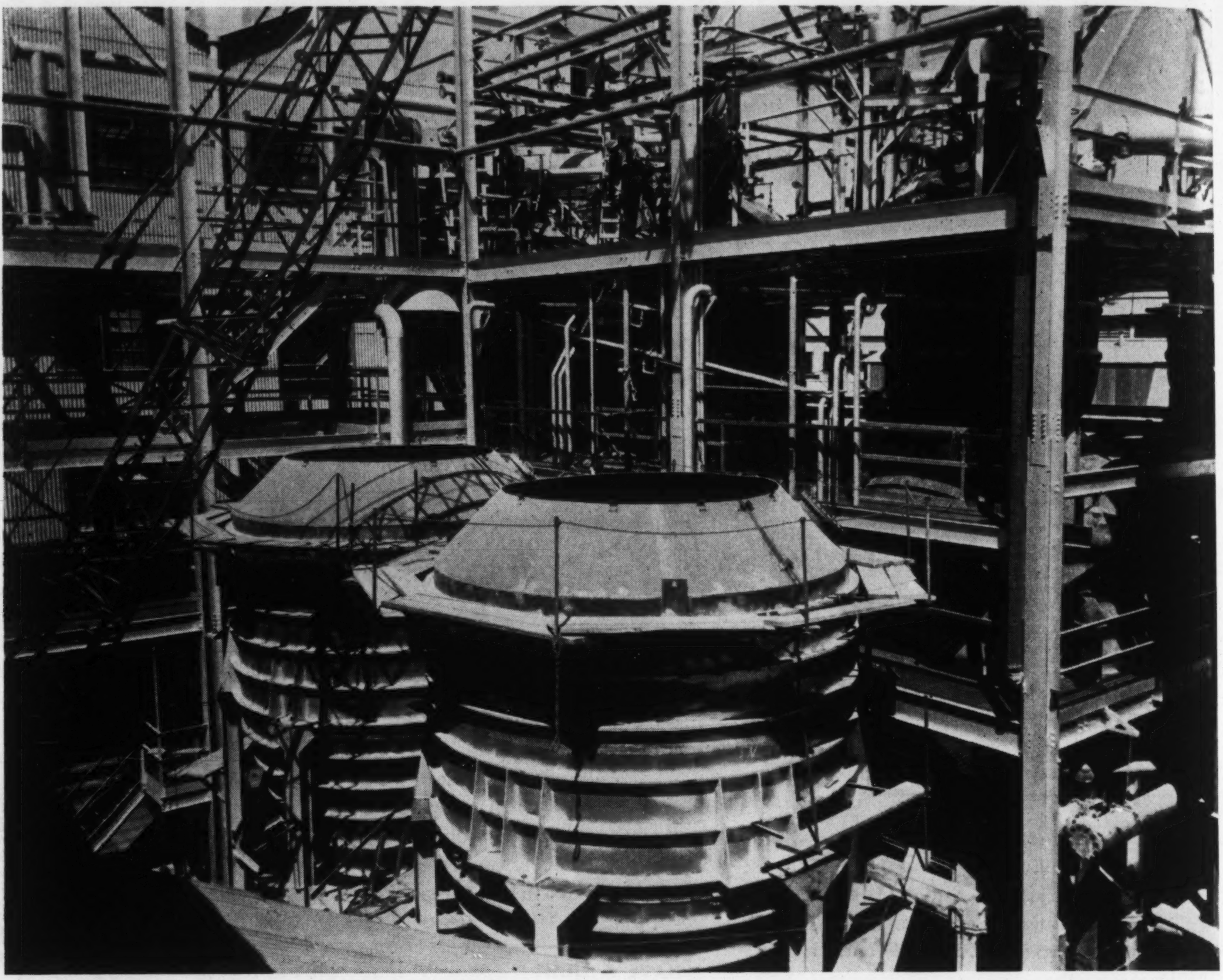
TRONA

LINDSAY CHEMICAL DIVISION

American Potash & Chemical Corporation

276 ANN STREET • WEST CHICAGO, ILLINOIS

For more information, turn to Reader Service card, circle No. 420



The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-corrosion cracking after a year.

No stress-relieving here —no stress-corrosion cracking!

Field-assembled from NEW AMPCO METAL GRADE 8

Improved Ampco Metal Grade 8 puts an entirely new slant on fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

At a major oil refinery, for example, field-welded piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-corrosion cracking.

New, patented Ampco Metal Grade 8 also simplifies field repairs and alterations. You can weld readily with any electric process, without pre-heat or post-heat and without hot-short cracking.

Talk this over with your Ampco field engineer. Or write *Ampco Metal, Inc., Dept. 11-H, Milwaukee 46, Wis. West Coast plant: Burbank, Calif.—Southwest plant: Garland (Dallas County), Texas.*

TS-6

AMPCO® AMPCO®

For more information, turn to Reader Service Card, circle No. 370

PRICES AND SUPPLY

...AT A GLANCE

ANNUAL CONSUMPTION OF POLYETHYLENE FILM should increase to about 300 million pounds by 1960, according to Vincent M. McCarthy, U. S. Industrial Chemicals Co. Mr. McCarthy based this prediction on the fact that improved techniques are now making the use of polyethylene film highly practical in applications for which it was previously considered impractical. In 1957, an estimated 200 million pounds of polyethylene film were used.

THE RECENT INCREASE IN COPPER PRICE—from 25 to 26½¢ per lb—may be the beginning of a series of price increases after two years of steady decreases. According to Charles Brinckerhoff, president of Anaconda Co., prices should definitely climb in the next six months. He suggested that 30-32¢ per lb would be an "agreeable" price for copper.

CONSUMPTION AND IMPORTS OF PLATINUM-GROUP METALS DROPPED SHARPLY in 1957 as compared to the all-time high levels of 1956. According to the Bureau of Mines, domestic use in 1957 was 3% below that of 1956 and imports were 33% lower. Platinum prices decreased considerably during the last year—from $103 to $67 per oz.

LEGISLATION TO IMPOSE A 4¢-PER-LB IMPORT DUTY ON ALUMINUM pig and ingot was recently introduced in the House of Representatives. According to Howard H. Baker (R, Tenn.), aluminum imported from France is now being offered in Chicago for 21¢ per lb and in New York for 21.3¢ per lb. Domestic aluminum is presently selling for 24¢ per lb.

PRICE OF POLYVINYL ALCOHOL HAS BEEN REDUCED by Du Pont in an attempt to "broaden markets." According to the company, five major grades have been reduced a total of from 4½ to 15%. The material is used primarily for adhesives, paper and textile sizes and in the manufacture of polyvinyl acetate emulsions.

THE FIRST INCREASE IN THE PRICE OF LEAD after nine consecutive decreases in more than two years was made by all major lead producers late in June. The new price is 11½¢ per lb, up from 11¢. The increase was reported to have resulted from a significant advance on the London market which in turn was prompted by reports that the U.S. was ready to institute a new stock-piling program.

The next quarterly tabular report on Prices of Materials will appear in the September issue.

NEW
LOW COST
"Utility"
HUCKBOLT
FASTENER
(AVAILABLE IN STEEL OR ALUMINUM)

OFFERS:

LOW COST—An economy model of the well known Huckbolt Fastener offering the desirable features of that fastener plus some special features of its own.

BROAD GRIP ADAPTABILITY—Six sturdy locking grooves on the fastener pin allow an unusual grip extension for each grip-size of pin.

THREE HEAD STYLES—The "Utility" fastener is offered in standard brazier, round and 90° countersunk heads to meet your requirements.

TWO COLLAR TYPES—The "Utility" fastener may be used with standard 2LC collar or with the 3LC which has a broad, sturdy, pre-engineered washer as an integral part.

FULL STRENGTH—The "Utility" fastener offers full rated tensile strength of the standard CL fastener, diameter for diameter.

CUTS STOCK REQUIREMENTS. Six annular locking grooves provide greater grip flexibility thus affording full coverage of your requirements with fewer grip sizes.

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For more information, turn to Reader Service card, circle No. 407

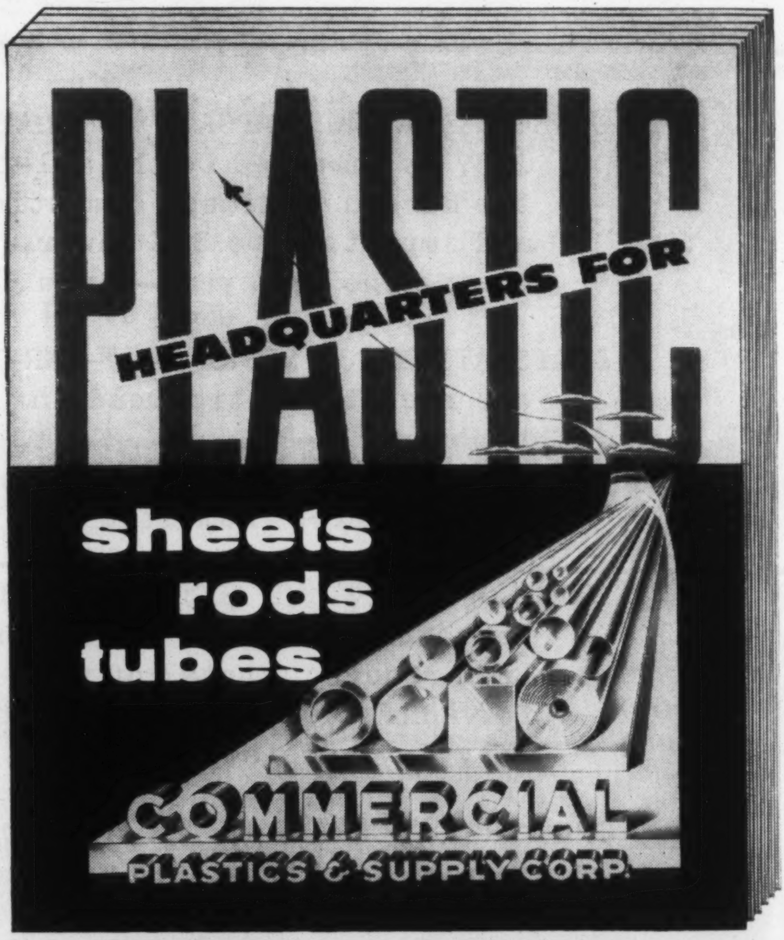
this is important enough to read twice!

Now, *for the first time*, you can obtain 1, 2, or a dozen prototype *high alumina ceramic* parts for development work in your own plant . . . at low cost.

This new service is available to "custom-make" any small-lot number of Frenchtown *engineered* ceramic parts to your exacting specifications. Here's an opportunity to put these look-ahead materials "through the mill" to help solve a materials problem for new or existing products, without the barrier of buying production run quantities. Want to know more? Write, outlining your problem. Ask, too, for a copy of our 4-page bulletin which describes the complete line of Frenchtown *engineered* ceramics.

frenchtown PORCELAIN COMPANY

FRENCHTOWN, NEW JERSEY



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Other News . . .

▸ Another cut in zinc production has been made by New Jersey Zinc Co. The latest curtailment reduces the company's production rate to about 50% of capacity. According to the company, the cut was "unavoidable" because domestic markets are being "flooded" by foreign imports, causing an oversupply at a time when consumption is decreasing.

▸ Price of sheathing fir plywood has been increased for the second time in only a few months. New price is $98 per 1000 sq ft, up from $96. In May, the price was raised to $96 from $93. A year ago, however, the price was $108. Sanded fir plywood prices remain unchanged at $64 per 1000 sq ft.

▸ Steel production capacity will have to be expanded approximately 45% by 1970 to meet expected needs, according to Prof. Donald R. G. Cowan, University of Michigan. As of January of this year, annual U.S. steel capacity was about 140 million net tons; by 1970, it will be about 200 million net tons.

▸ Prices of low density polyethylene resins have been reduced by Eastman Chemical Products, Inc. and Allied Chemical Corp. Allied's reductions—from 35¢ down to 30¢ per lb—affect A-C Grades 6A and 617A. Eastman's reductions apply to Epolene N—reduced from 45¢ to 35¢ per lb, and Epolene E—reduced from 48¢ to 40¢ per lb.

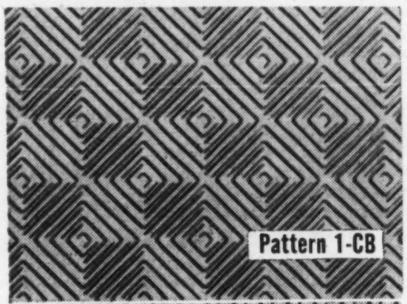
▸ U.S. production of tin plate will be increased by more than 60% when Inland Steel Co.'s new tin mill is completed some time in 1960. According to Joseph L. Block, president, the expansion is being made to meet the expected "rapid growth in the use of tin-coated steel for cans." When complete, the new tin mill will have an annual capacity of 165,000 tons, bringing the company's total annual capacity up to 435,000 tons.

▸ The $6-per-ton steel increase which Alan Wood Steel Co. had scheduled for July 7 was cancelled because "other steel producers did not go along." The company, ranking 23rd in steel production capacity, had planned to raise prices in order to help "offset mid-year wage boosts," but it conceded that it would backtrack if its "large competitors" failed to hike prices too.

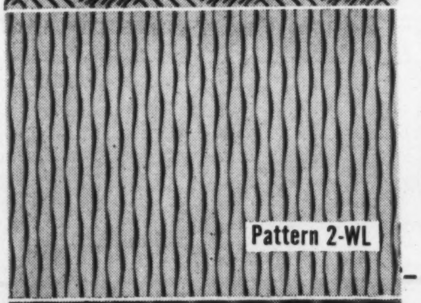
SPARKLING BEAUTY

achieved by Good Design and

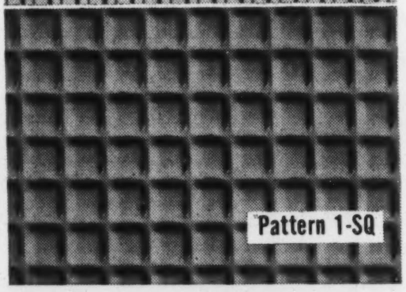
RIGID-tex METAL



Pattern 1-CB



Pattern 2-WL



Pattern 1-SQ

This pattern is used for the instrument panel and the door handwheel dome on Autoclave illustrated above.

The two go hand in hand. RIGID-tex Metal has texture that imparts sparkling brilliance; color that adds irridescent beauty!

Good design must also be practical. Here too, RIGID-tex Metal contributes with strength far greater than flat metal, greater yield and impact strength, greater rigidity . . . and even more than this . . . a mar-resistant surface that conceals scratches and smudges to provide a permanence of finish and beauty never before attained.

Let RIGID-tex Metal help you achieve more beautiful . . . more practical . . . more outstanding designs. There are over 40 standard patterns from which to choose — in all metals — all colors. Write for literature and samples today!

Tell me more about RIGID-tex Metal.

☐ Send a copy of "Pattern Selector" showing all the standard patterns.

☐ Send a sample of RIGID-tex Metal.

☐ Send name of nearest distributor.

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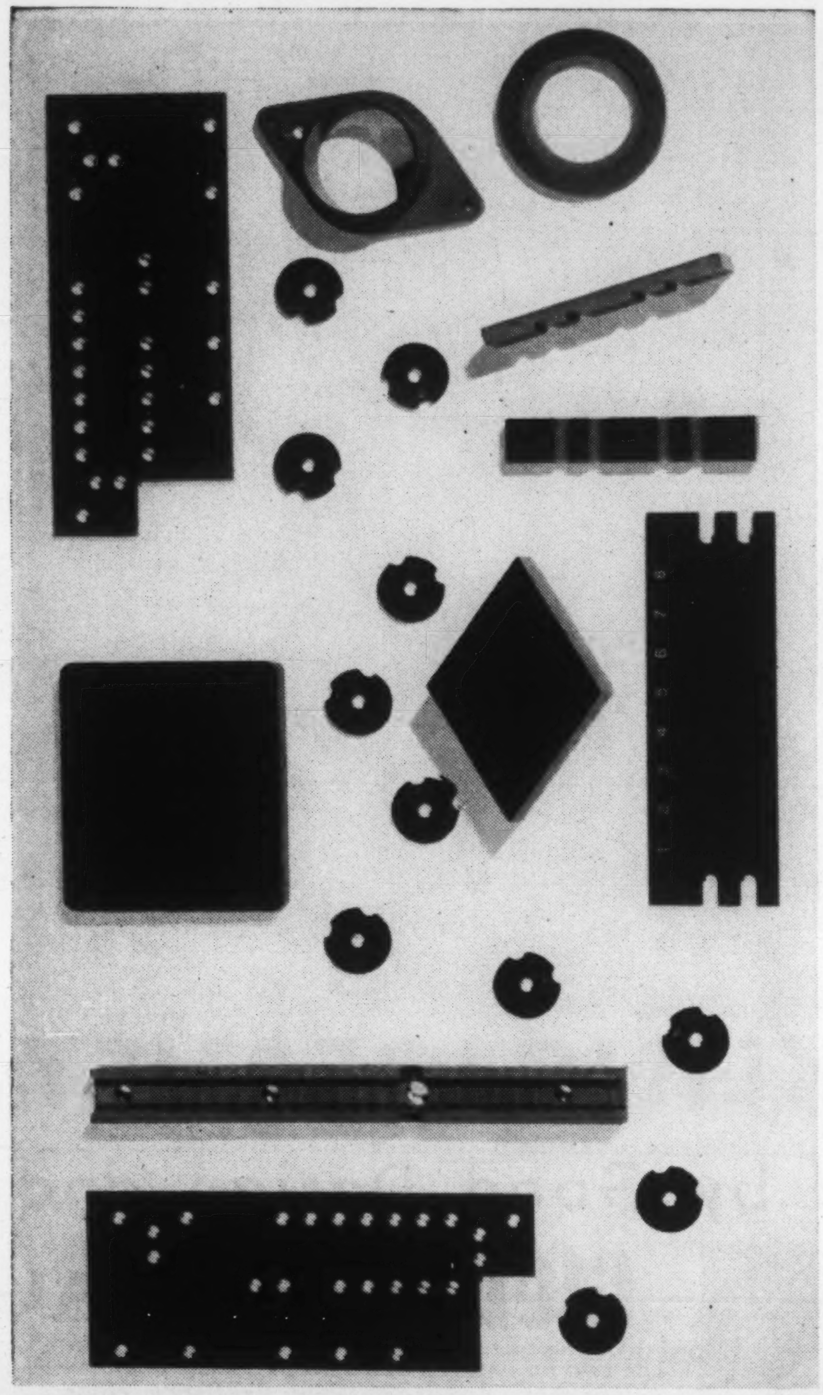

Fabricated by CDF. Near the presses that produced the Dilecto laminates, these paper-base parts were machined to close tolerances by CDF specialists . . . quickly, accurately, economically for the purchasers. This is a random selection from the five grades described in the table below.

CDF Dilecto® paper-base laminates for the workhorse insulation jobs

For everyday mechanical-electrical parts that receive tough punishment and must have excellent physical and dielectric properties at low cost, the CDF phenolic paper-base line is outstanding.

Economy. CDF paper-base grades machine readily into intricate parts. Some are flame-retardant. Others are especially adaptable for punching. All are economical for the value delivered.

Fabrication Facilities. CDF has excellent and extensive plastics-fabrication facilities for turning out finished Dilecto parts to your specifications—better and more economically than you can do it yourself. Save the time and trouble of intricate fabrication by using CDF's specialized facilities.

See Sweet's, Electronics Buyers' Guide, and the other directories for the phone number of the CDF sales engineer nearest you. Or send us your print or problem direct, and we'll return a recommendation of the right Dilecto grade for your need.

CDF makes Di-Clad* printed-circuit laminates, Diamond® Vulcanized Fibre, CDF products of Teflon†, flexible insulating tapes, Dilecto® laminated plastics, Celoron® molded products, Micabond® mica products, Spiral Tubing, Vulcoid®.

*Trademark of Continental-Diamond Fibre Corporation
†Du Pont trademark for its TFE-fluorocarbon resin

CONTINENTAL-DIAMOND FIBRE
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Typical Property Values—Dilecto Paper-Base Laminates in Sheet Form

	X-13 (NEMA X)	XP-13 (NEMA P)	XX-13 (NEMA XX)	XX-13 FR (Fire-retardant) (NEMA XX)	XXXP-28 (NEMA XXXP)
ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16" thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

For more information, turn to Reader Service card, circle No. 371

News OF INDUSTRY

New Laboratory Designed for Corrosion Research

A new laboratory, equipped to perform research aimed at solving specific corrosion problems, has been placed in operation by Carpenter Steel Co. According to the company, the new facility has a two-fold purpose: 1) to develop information on the performance and characteristics of metals so that the user can make the right selection of materials, and 2) to perform studies leading to the improvement of existing, and development of new, corrosion resistant alloys.

The laboratory will be used primarily to uncover new information on such things as stress corrosion cracking in high temperature alloys, pitting, intergranular corrosion and preferential attack on metals. According to Carpenter, most of the laboratory's facilities will be used to solve particular customer problems, i.e., to determine the best possible alloy for a specific application; in some cases, the laboratory will develop special, tailor-made alloys to satisfy special corrosion problems.

Two unique pieces of equipment are expected to provide much new and valuable information in extremely short periods of time as compared to previous methods: 1) a Corrosometer, used to measure the corrosion rate of metals, is said to be capable of obtaining in 24 to 48 hr results that previously required 2 to 6 weeks of testing, and 2) specially designed heat transfer equipment can measure the corrosion rate of metals at the service temperature of the metal itself. (For further details, see p 154).

In addition to solving specific problems, studies at the new laboratory are expected to contribute a great deal to the general knowledge and development of metals for critical applications in the atomic energy, guided missile and aircraft fields.

HEAT TREATING
A
B
C
MEDOYLE

"By the way, that sample in C furnace has a pretty high thermal coefficient."

Tailor-Made Materials Grow in Importance

The development of tailor-made materials to meet specific needs was the subject of a recent symposium on Materials Research Frontiers.

The symposium, which was part of the 1958 annual meeting of the American Society for Testing Materials, was conducted by eight authorities in the materials field and covered the most recent advances in engineering materials and probable

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may help you save up to 50% in steel cost by comparing the weight savings of hollow tubing versus solid stock.

By replacing solid rod with tubing in shafting (2¼" O.D. x .134" wall) a large blower manufacturer effected a 50% savings in costs. Physical performance remained unchanged. Perhaps you, too, can effect comparable or even greater savings. Write today for this free and important table to reduce steel costs!

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future trends in materials developments. The most significant trend discussed was the commercial development in recent years of a number of tailor-made materials, particularly in the plastics and rubber fields. The consensus was that this trend will certainly continue as greater demands for special service properties are placed on materials.

The ASTM meeting drew an estimated 5000 persons who heard a total of more than 200 papers on materials research and technology.

Western Tool Show Set for Late September

The 1958 Western Tool Show and semi-annual meeting of the American Society of Tool Engineers is scheduled to be held Sept 29-Oct 3 at the Shrine Exposition Hall, Los Angeles.

The theme of the show and meeting is "Tooling for the Space Age." Some of the subjects to be covered at the technical sessions include "Tooling for Airframes," "Sandwich Construction," "Tooling for Electronics," and "Plastics in Tooling Applications."

For further information, contact Harry E. Conrad, executive secretary, American Society of Tool Engineers, 10700 Puritan Ave., Detroit.

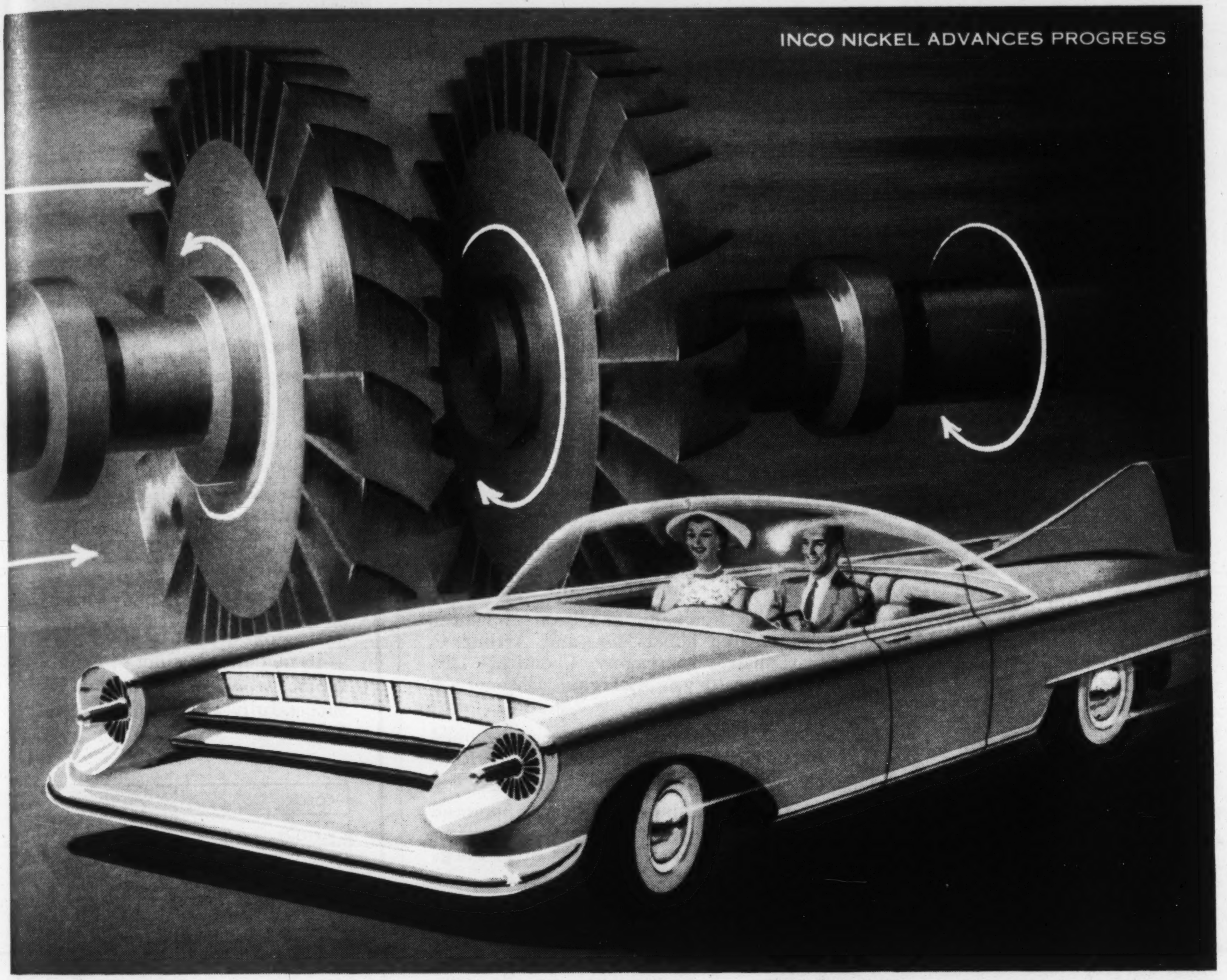
Steatite Standards Are Now Available

Another example of how trade associations may perform valuable services to industry in general is the first edition of the *Standards of the Steatite Manufacturers Association.*

According to the Association, the new edition contains much information that has never been published anywhere before. Included in the publication are standards covering properties, test methods, definitions, design criteria, etc.

Copies may be obtained by forwarding $1 to George P. Byrne, Jr., secretary, Steatite Manufacturers Assn., 53 Park Place, New York 7, N. Y.

(News of Engineers on p 186)



This "windmill" or turbine, spun by hot gas, powers the turbocar. For such a hot spot, designers depend on Nickel to help them solve heat-resistance problems.

How Inco Nickel is helping develop your new gas turbine car of tomorrow

It will be power-packed: the gas turbine engine in your dream car of the future. In tomorrow's trucks and buses, too.

Only one spark plug—runs on kerosene

This new, power-packed engine is much lighter, much smaller than yours. It has far fewer parts. No pistons. No water system. Only one spark plug. And it runs on lower-grade fuels like kerosene. Not yet in production!

Before this dream car becomes a showroom reality, engineers have a number of big problems to solve.

One of the engineers' problems—the one Inco Nickel is helping with—is metals. *Heat-resisting metals!*

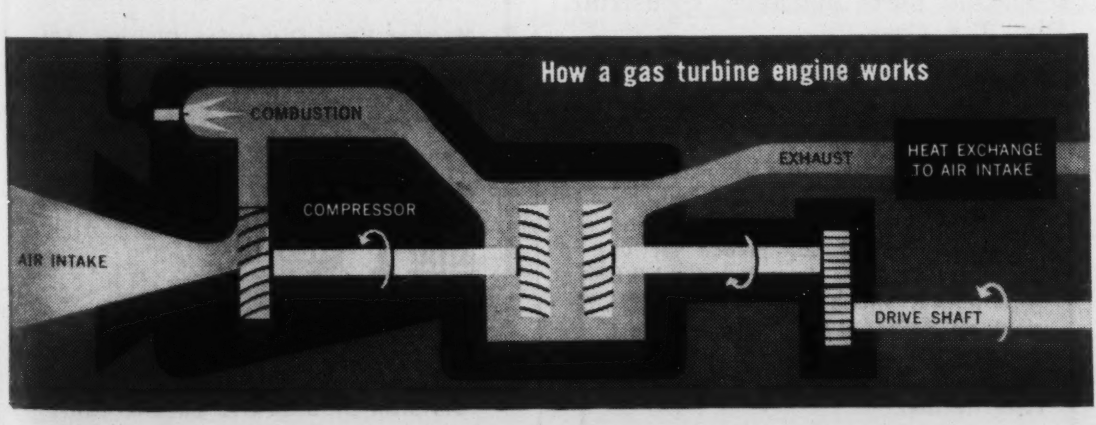
Gas turbine engines operate up to 1600 degrees F. These temperatures step up corrosion. So the job is to develop alloys that can carry the load—that resist corrosion—at these jet-high temperatures.

Nickel-containing alloys are just such metals

This has been proved by (1) International Nickel Company's *basic* research. By (2) the experience of jet engine designers. More proof comes from the research efforts of the automotive and aviation industries . . .

But the uses of nickel-containing alloys *are by no means limited to these industries.* There's a place for them in any field where heat, corrosion, stress and fatigue proves troublesome. Our new booklet, "High Temperatures Spur Use of Nickel-Base Alloys," points up this versatility. Write for a copy.

The International Nickel Company, Inc.,
New York 5, N.Y.



Inco Nickel

Makes metals perform better longer

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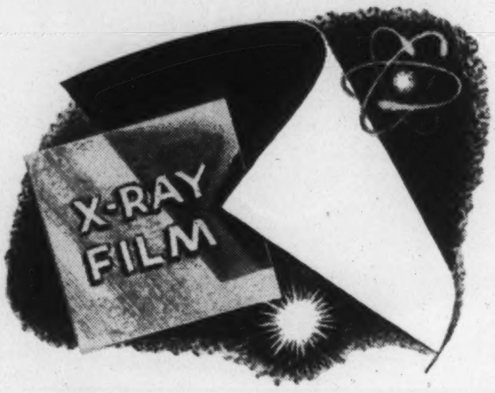
CREATIVE IMAGINATION *in Specialty* PAPERS★



★ *Can paper be held to several critical limits simultaneously?*

A leading manufacturer of x-ray film needed a wrapping paper that would be 1) opaque; 2) free of trace radioactivity commonly present in paper; and 3) of uniform thinness for ease of packing and dispensing film. Knowlton came up with a duplex paper — pure white on one side, pure black on the other — which consistently meets all three specifications.

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News OF INDUSTRY

Engineers

Dr. Hermann V. Boenig is now director of research and development, International Molded Plastics, Inc.

Vincent Moore has been named chief of design, Hamilton Standard Div., United Aircraft Corp.

Dale L. Waugh has been appointed chief belt research and development engineer, Dayton Rubber Co.

T. Ross Welch has been named general manager, TC Components Div., Brubaker Electronics Co., sub. of Telecomputing Corp.

Hans Neumann has been appointed research supervisor, and **Arthur C. Lansing,** manager, Chemical Div. Laboratory, Michigan Chrome & Chemical Co.

S. William Riley has been named chief project engineer, Quaker Rubber Div., H. K. Porter Co., Inc.

Louis D. Linta has been appointed manager of quality control, Forging Div., Transue & Williams Steel Forging Corp.

John E. Voyles is now senior engineer, Control Data Corp.

L. William Ullrich has been named head of Electromold Corp.'s new Product Research and Development Dept.

Dr. George W. Beste has been appointed general manager, research and development operations, Ethyl Corp.

Frederick W. Howells has been named manager of Singer Mfg. Co.'s new Military Products Div.

George C. Zentz, is now supervisor, Methods Dept., Clearing Machine Corp., a Div. of U. S. Industries, Inc.

James D. Doughty has been appointed manager of quality control, Fiber Glass Div., Pittsburgh Plate Glass Co.

Robert F. Kehrer has been named industrial parts manager, Industrial Div., J. I. Case Co.

Emmett P. Medlock, Jr., has been appointed plant manager, Circuit In-

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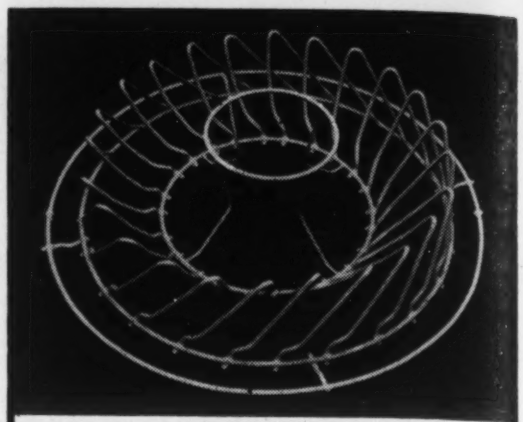

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COLD PROPERTIES	FLEXIBLE AT 65° F
LIGHT RESISTANCE	GOOD
TYPE OF SURFACE	DRY AND GLOSSY
TENSILE STRENGTH	VERY GOOD
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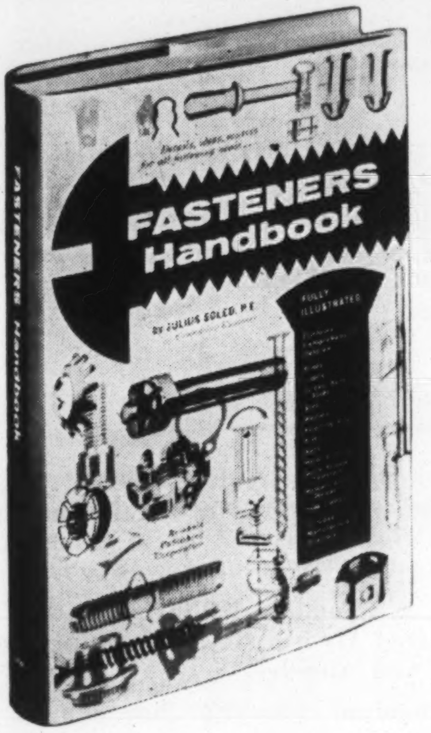

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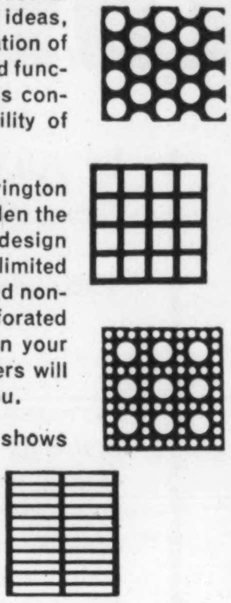

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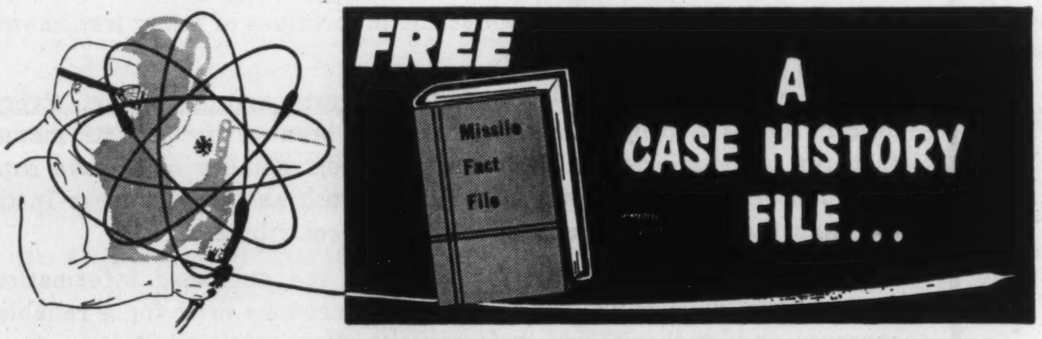

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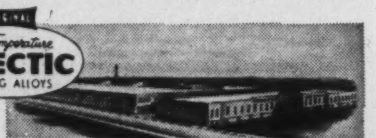

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News OF INDUSTRY

struments Inc., a subsidiary of International Resistance Co.

Allan I. Benson has been promoted to manager, scientific applications, Computer Dept., General Electric Co.

Companies

MacDermid Western Inc., a wholly owned subsidiary of **MacDermid Inc.**, has been absorbed by its parent company.

U. S. Chemical Milling Corp. has acquired **Hydro Metal Spinning Corp. of Los Angeles.**

American Can Co. has moved its Midwestern offices to a new building at 200 S. Michigan Ave., Chicago.

Dow Chemical Co. has purchased the common stock of **Extruders Inc.**, which will be operated as a Dow subsidiary.

Philadelphia Gear Corp. is the new name of Philadelphia Gear Works, Inc.

Shallcross Mfg. Co. is moving its entire operation to a new 41,000-sq ft plant in Selma, N. C.

Bee Chemical Co. announces that **Logo, Inc.**, a wholly owned subsidiary, has been dissolved and merged into its parent company.

Epsco, Inc. has acquired **Edin Co.**, Worcester, Mass.

Lear, Inc. has established a new division, **Lear Astronics Div.**, located in Santa Monica, Calif.

Switchcraft, Inc. has moved to larger quarters at 5555 N. Elston Ave., Chicago 30.

Narmco, Inc. has moved into its new $500,000 research and development center in San Diego, Calif.

Hercules Powder Co. will construct a new facility for the development and production of solid propellants for long range rockets and missiles.

National Vulcanized Fibre Co. has moved its Midwest headquarters to a newly constructed plant in suburban Chicago.

Universal-Cyclops Steel Corp. has organized a new **Refractomet Div.** to increase participation in the commercial development of refractory and reactive metals.

Electronic Instrumentation Co. is the new name of Electronic Instrumentation Div., Ramo-Wooldridge Corp. The company will continue to oper-

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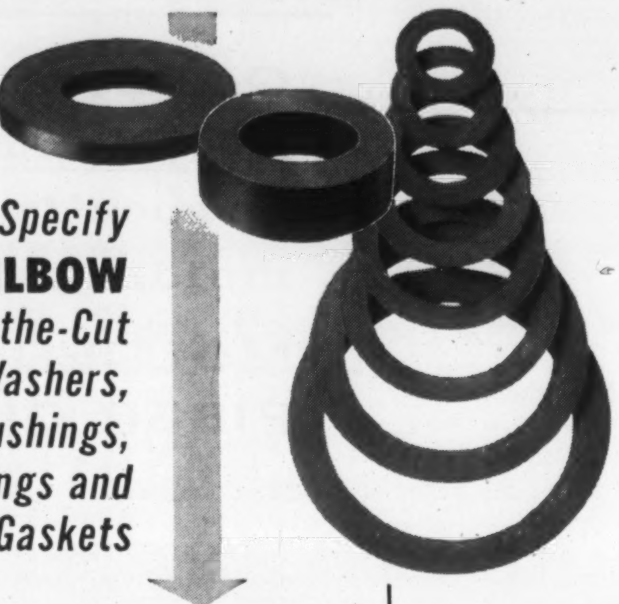

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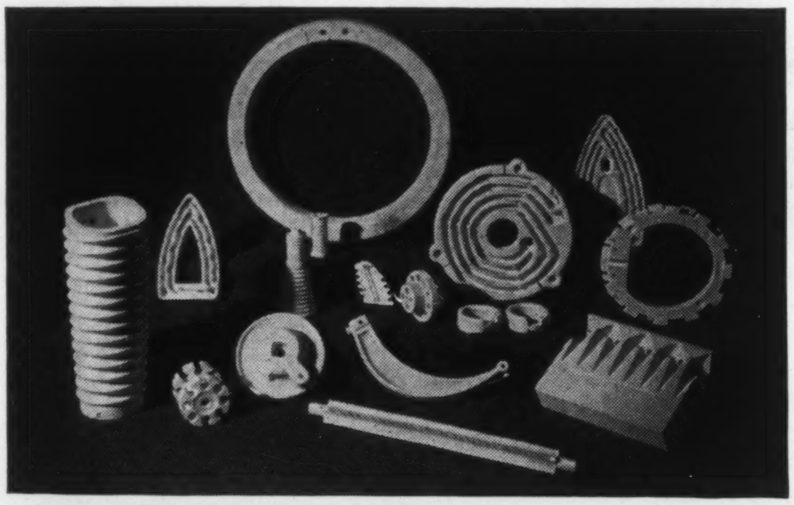

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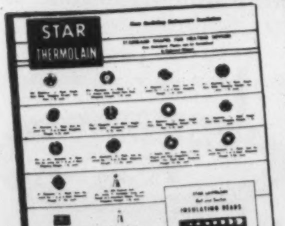

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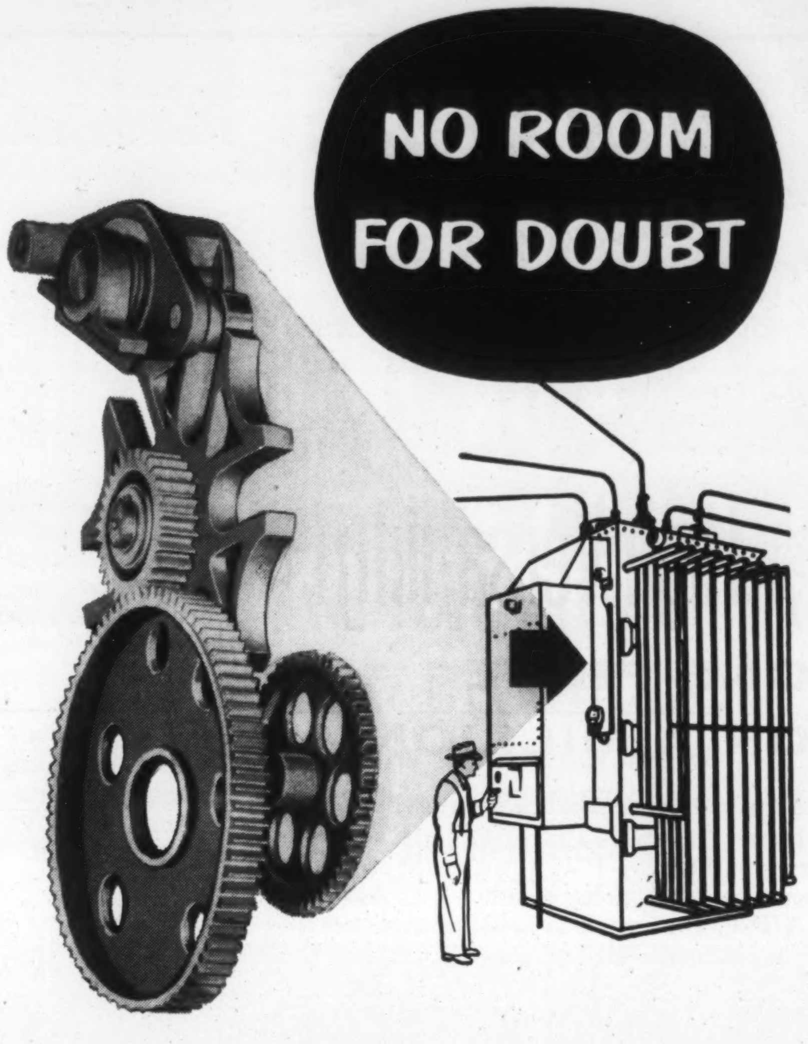

Gears in this Geneva gear drive have to be rugged! They change taps to correct voltage in General Electric high capacity step voltage regulators, where failure could affect the performance of millions of dollars worth of electrical equipment in homes and plants.

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ate as a division of Ramo-Wooldridge.

Strom Steel Ball Co. has transferred its Cicero, Ill., facilities to a new plant in Erwin, Tenn.

Societies

American Society of Tool Engineers has elected the following 1958-59 officers: president and chairman of the board—George A. Goodwin, Master Electric Co.; vice presidents—Wayne Ewing, Arrowsmith Tool & Die Co.; H. Dale Long, Scully-Jones & Co.; William Moreland, F. E. Myers & Bros. Co.; David A. Schrom, Borg-Warner Corp.; treasurer—Philip R. Marsilius, Producto Machine Co.; secretary—Charles M. Smillie, C. M. Smillie Co.; executive secretary—Harry E. Conrad; and assistant executive secretary—Allan Ray Putnam.

Magnesium Association has announced the following officers: president—Otis E. Grant, Magnode Products Inc.; vice presidents—Charles A. Howe, Hills-McCanna Co.; John Thomson, Dominion Magnesium Ltd.; and treasurer—Norman G. Gzowski, Garfield Alloys Inc. Directors are: Norton Watson, Robert Michell Co.; A. W. Winston, Dow Chemical Co.; D. T. Wellman, Wellman Bronze & Aluminum; Paul Hargitt, Light Metals Inc.; Arley Morse, Modern Light Metals; J. A. Cosman, Superior Bearing Bronze Co.; George Kurr, American Smelting & Refining Co.

Drop Forging Association has elected the following directors: Alexander F. Sherys, Porter Forge & Furnace, Inc.; Emery M. Cook, Transue & Williams Steel Forging Corp.; Earl W. Cote, Webb Forging Co.; Edward R. Anderson, American Brake Shoe Co.; William M. Croft, California Drop Forge Co.; and Harold W. Schmid, General Metals Corp.

American Institute of Mining, Metallurgical and Petroleum Engineers, National Open Hearth Steel Committee, has announced the following winners of two annual awards: F. B. McKune Memorial Award—R. W. Joseph and L. J. Trilli, Inland Steel Co., for their paper, "A Study of Wall Erosion in Wide Slab Molds"; and Open Hearth Conference Award—R. E. Stoll and E. C. Rudolphy, U. S. Steel Corp., for their paper, "Effect of Nozzle Characteristics on Steel Pouring Streams."

(News of Meetings on p 192)

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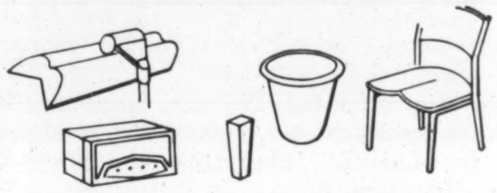

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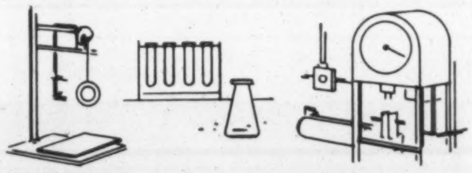

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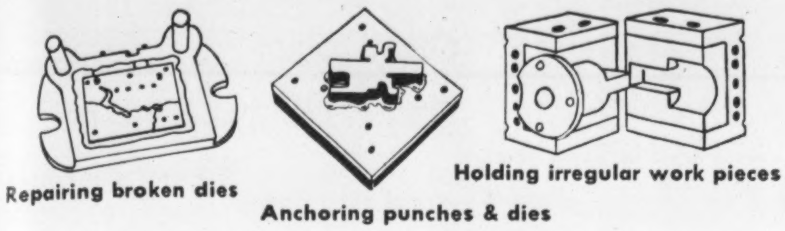

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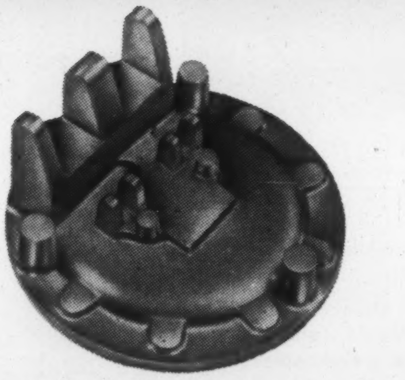

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News OF INDUSTRY

Meetings

SOCIETY OF AUTOMOTIVE ENGINEERS, national West Coast meeting. Los Angeles. Aug 11-14.

CONFERENCE ON ELECTRONIC STANDARDS AND MEASUREMENTS, American Institute of Electrical Engineers, Institute of Radio Engineers and National Bureau of Standards. Boulder, Colo. Aug 13-15.

WESTERN ELECTRONIC SHOW AND CONVENTION, Los Angeles. Aug. 19.

AMERICAN CHEMICAL SOCIETY, national chemical exposition and conference. Chicago. Sept 7-12.

SOCIETY OF AUTOMOTIVE ENGINEERS, national farm, construction and industrial machinery meeting, and production forum and display. Milwaukee. Sept 8-11.

AMERICAN DIE CASTING INSTITUTE, annual meeting. Chicago. Sept 10-11.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, INC., Rocky Mountain minerals conference. Salt Lake City. Sept 10-12.

AMERICAN ROCKET SOCIETY, INC., fall meeting. Detroit. Sept 14-18.

INSTRUMENT SOCIETY OF AMERICA, 13th annual instrument automation conference and exhibit. Philadelphia. Sept 15-19.

STEEL FOUNDERS' SOCIETY OF AMERICA, 56th fall meeting. Hot Springs, Va. Sept 22-23.

IRON AND STEEL EXPOSITION, Assn. of Iron and Steel Engineers. Cleveland. Sept 23-26.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept 25-27.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, power division conference. Boston. Sept 28-Oct 1.

ELECTROCHEMICAL SOCIETY, fall meeting. Ottawa, Ont. Sept 28-Oct 2.

PRESSED METAL INSTITUTE, annual meeting. Sea Island, Ga. Sept 28-Oct 2.

AMERICAN SOCIETY OF TOOL ENGINEERS, semi-annual meeting and western tool show. Los Angeles. Sept 29-Oct 3.

SOCIETY OF AUTOMOTIVE ENGINEERS, national aeronautic meeting, aeronautic production forum and aircraft engineering display. Los Angeles. Sept 29-Oct 3.

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How DOLLIN DIE-CASTINGS add a quality look to a quality tool - - at low cost

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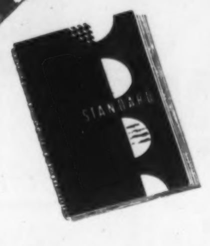

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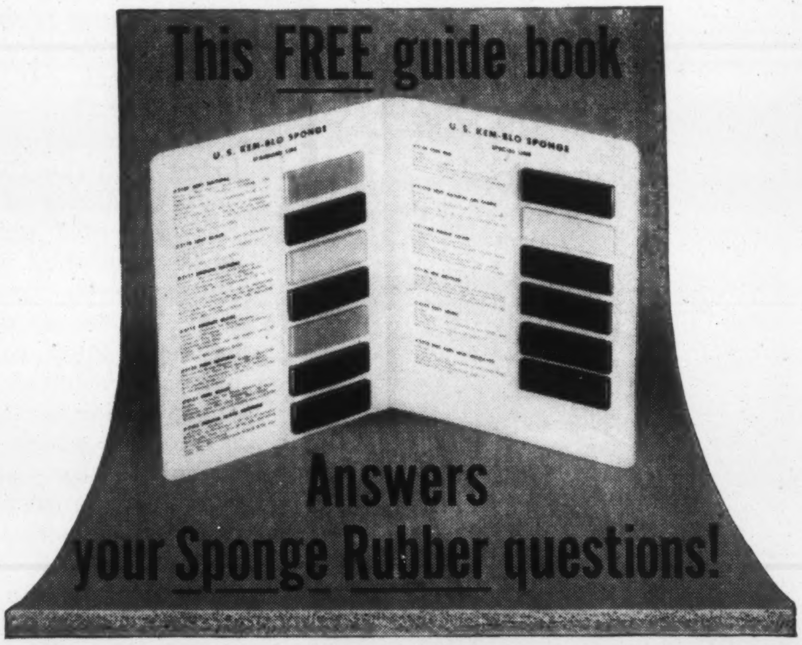

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TECHNICAL LITERATURE

(cont'd from p 43)

Books

Aluminum Sheet and Plate Product Information: 2nd Edition. *Kaiser Aluminum & Chemical Sales, Inc., Chicago, 1958. Cloth, 5½ by 8½ in., 318 pp.*

The purpose of this book, the first complete revision of a book first published in 1953, is to acquaint the design engineer with the properties and uses of aluminum sheet and plate alloys. Numerous tables, presenting a wealth of information on corrosion resistance, Government and commercial specifications, chemical compositions, mechanical properties and dimensions, make the book a ready reference.

Other subjects covered in the book include: 1) handling, storing and fabrication of aluminum; 2) joining and fastening of aluminum; and 3) surface finishes for aluminum. The book contains an index and a section on nomenclature and definitions relating to aluminum.

Handbook of Material Trade Names: Supplement 2. *O. T. Zimmerman and Irvin Lavine. Industrial Research Service Inc., Dover, N. H., 1957. Cloth, 7½ by 10½ in., 356 pp. Price $13.75*

The present volume is intended to bring both the 1953 edition of *Handbook of Material Trade Names* and *Supplement 1* up-to-date. The three books combined contain useful information on the properties and uses of over 25,000 products manufactured by some 2000 companies. Like the previous volumes, Supplement 2 has three major sections: 1) trade name section in which products are listed alphabetically and described; 2) classification section in which products are classified according to their major uses and compositions; and 3) directory section which gives the address of each manufacturer and distributor whose products are described.

In addition, the book has a section entitled "Products Withdrawn from the Market." In this section, all products described in the 1953 edition and Supplement 1 which are no longer available are listed alphabetically for ready reference.

Stainless Steel Fabrication. *Allegheny Ludlum Steel Corp., Pittsburgh. 1958. 386 pp.*

Illustrated with more than 140 photographs, 120 charts, and 200 diagrams, this book presents detailed

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information on all common methods and practices used to fabricate stainless steel into usable products. The book has nine chapters which contain information on cutting, joining, cold and hot forming, heat treating and machining operations.

Reports

Vacuum melted metals VACUUM MELTING. *1957. 142 pp. Available from Vacuum Melting, 1383 Panther Rd., Rydal, Pa. Price $7.50*

Although this report is concerned primarily with the technique, economics and history of vacuum melting, it does contain an interesting chapter on the properties and uses of vacuum melted steel, iron, uranium, titanium, zirconium, molybdenum, copper and nickel.

Survey of corrosion 1954-1955 BIBLIOGRAPHIC SURVEY OF CORROSION. *1957. 468 pp. National Assn. of Corrosion Engineers, 1061 M & M Bldg., Houston 2, Tex. Price $20 (NACE Publication No. 58-1)*

A selection of 4287 abstracts of articles on corrosion prevention published in 1954-1955 are compiled in this volume.

Creep studies CREEP OF ALUMINUM-COPPER ALLOYS DURING AGE HARDENING. *E. E. Underwood, L. L. Marsh and G. K. Manning, Battelle Memorial Institute. Feb '58. 73 pp. Available from National Advisory Committee for Aeronautics, 1512 H St. NW, Washington 25, D. C. (TN 4036)*

A study of the interrelation of aging during creep and of creep during aging in polycrystalline aluminum alloys containing 1 to 4% copper. Experimental procedures included interrupted creep tests, tensile tests of crept specimens, and hardness measurements on unstressed and stressed aged alloys.

Properties of titanium THE PROPERTIES OF TITANIUM ALLOYS AT ELEVATED TEMPERATURES. *R. R. Schwartzberg, F. C. Holden, H. R. Ogden and R. I. Jaffee, Titanium Metallurgical Laboratory, Battelle Memorial Institute. Sept '57. 228 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D.C. Price $6 (PB 121634)*

Literature survey on the mechanical properties of titanium alloys at high temperatures. A discussion of thermal stability is included.

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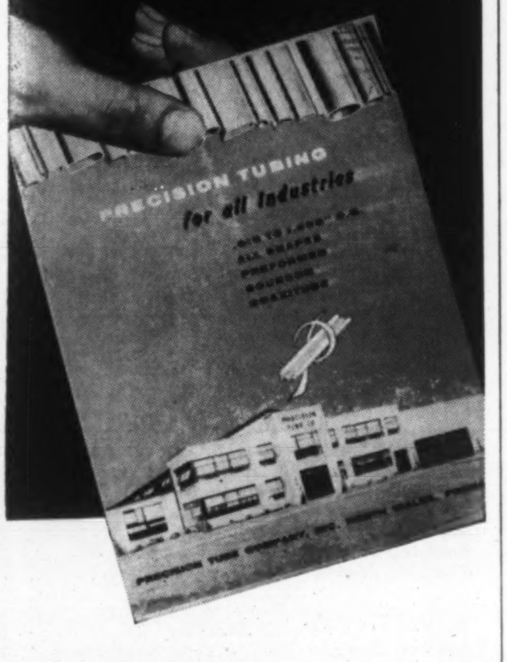

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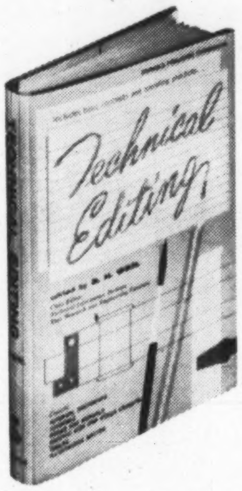

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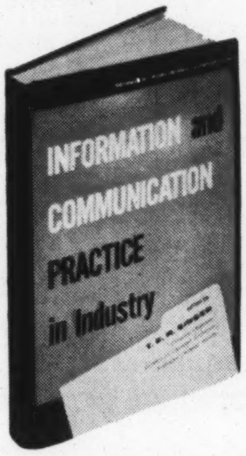

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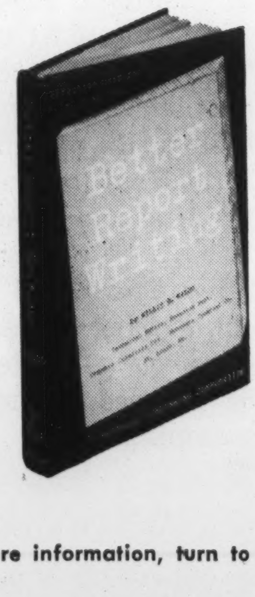

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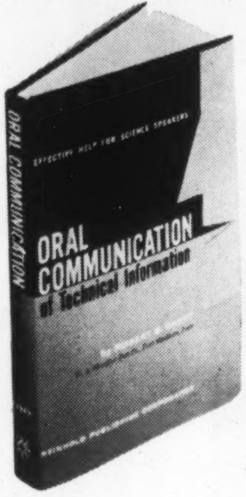

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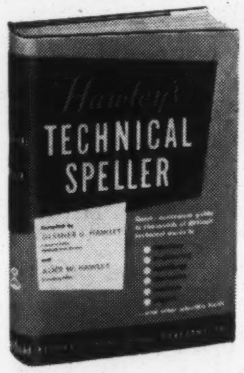

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THE LAST WORD

by H. R. Clauser, *Editor*

Selling in the Lab

This is indeed the age of service to the customer. At least this seems to be so in the materials fields where tailoring materials to fit the need is becoming almost commonplace. During the past few months we visited two new laboratories that are primarily designed for just this purpose.

At Carpenter Steel's new corrosion laboratory, most of the facilities will be used in researching specific customer problems. By working closely with the customer, the lab will determine what alloy is best suited for a particular application; and, where volume warrants it, they will even try to cook up a special alloy to meet a specific set of corrosion conditions.

Even more elaborate is Du Pont's new 5 million dollar laboratory built to provide a center for development work on problems of customers of the electrochemicals and pigments departments. Included in their facilities are large demonstration areas and even equipment that duplicates on a semi-works scale their customers' operations. A most significant sidelight of the Du Pont lab is that it also serves as both a training center and source for salesmen.

Changing with the Times

Technical societies, being composed of people, are generally reluctant to change. But change they must if they are to progress or, indeed, survive. A recent policy change in the American Welding Society is a good example of a technical organization adjusting its policies to encompass new developments in materials.

Although predominantly a metals society, the AWS has now recognized the importance of adhesive bonding and plastics in modern industry. They, therefore, have decided to extend their activities to include adhesives and welding of plastics, and to cover them in the Welding Handbook.

To our way of thinking, the AWS official recognition of plastics is quite significant. In general, metals groups have preferred to politely ignore the nonmetallics. We hope the AWS action is indicative of a trend towards a change in this attitude.

Us Dopes

The gloomiest bit of information this month comes from an item in *Science News Letter* reporting results of tests conducted to rate the logical reasoning powers of various groups and professions. The sad fact is that engineers scored only 25.8 as compared to 27.3 for lawyers and 28.6 for all college graduates.

Add this statistic to the popular notion that engineers don't read, can't write, can't speak, and are unsociable, and it begins to look as if engineers are a pretty worthless lot. Anyone want to buy a slide rule cheap?

Farm System for Engineers

The competition for bright graduating engineers in some instances has led to attractive inducements that remind one of the bonus player deals common with the big league ball clubs. Now, J. H. Flynn, director of student personnel services at Boston University's College of Industrial Technology, suggests that large companies adopt another major league baseball tactic—the farm system. He recommends that young engineers be farmed out to small subcontracting companies for training and seasoning before being brought up into the big leagues. He believes such an arrangement would make for more efficient use of engineering talent. I suppose it follows that engineers on a big league team who goofed would be shipped down to the farm for additional seasoning.